CEREAL SCIENCE today

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AMERICAN ASSOCIATION
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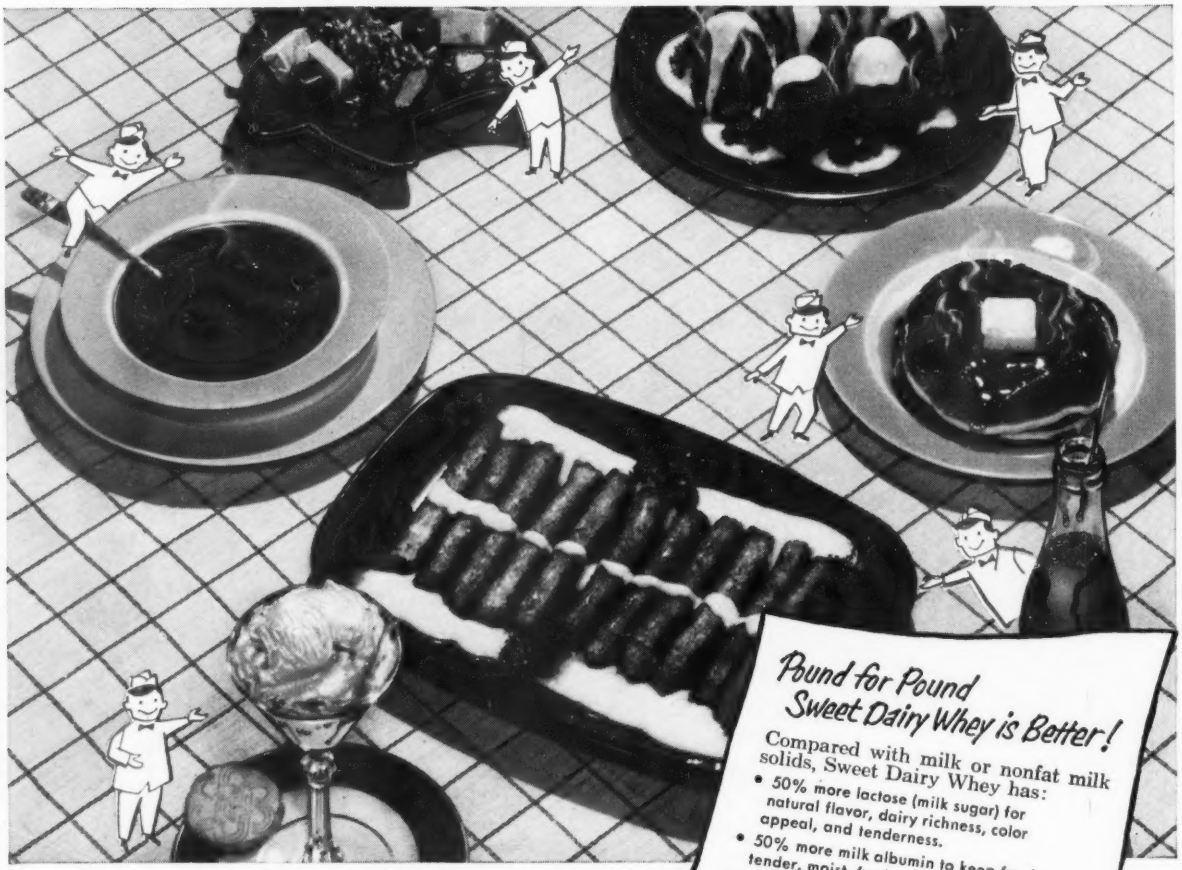

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INSIDE SCIENCE

A New Chapter In
The Vital Story of Bread Enrichment

by Science Writer

Lighting 15 Candles

1956 is a milestone in the trend to nutritional improvement of processed foods. It marks the 15th Anniversary of white bread and white flour "enrichment" in the United States.

Back in the late 1930's millers and bakers began the restoration of vitamin B_1 to their foods. Later vitamin B_2, niacin and iron were included. Then in 1941 the concept of "enrichment" came into being: restoration of B_1, niacin and iron and fortification with a *higher* amount of B_2 than originally present in the wheat berry.

The baking and milling industries deserve the gratitude of the nation for thus insuring better foods for the nation's better health.

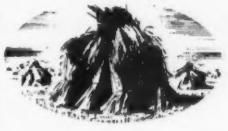
What Diet Experts Say

Physicians, dietitians, nutritionists, public health experts have supported enrichment from the start and continue to approve the practice. For example, a prominent public health nutritionist has said:

> *". . . my first and most important suggestion to you—continue not only to enrich your white bread but continue to promote enrichment until all white bread in the United States is enriched, and continue to tell the public repeatedly and more effectively about the nutritional value of enriched white bread."*

The U. S. Department of Agriculture credits the enrichment of white flour and bread for major improvements in the per capita daily food supply. Said the Department in the 1955 outlook issue of its publication "The National Food Situation"—"Enrichment and fortification of grain products continue to make an important contribution to the nutritive value of diets, especially in thiamine."

Why Enrich?



Americans want *white* bread to eat. Millers and bakers want *white* flour because it keeps better and bakes better. To produce this fine product, millers must process the grain to a high degree of whiteness—unavoidably milling out some values known to be necessary for good health.

Enrichment restores the important lost nutrients. It puts white flour and bread on a par with—in many cases actually ahead of—whole wheat products in their content of these factors which are necessary to good health and well-being:

Thiamine (vitamin B_1)	Niacin (another "B" vitamin)
Riboflavin (vitamin B_2)	Iron

What Values Do the Enriching Vitamins and Iron Have?

Thiamine is the vitamin which helps build physical and mental health. Essential for normal appetite, intestinal activity and sound nerves.

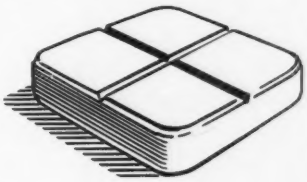
Riboflavin helps promote healthy body tissues and proper eye function.

Niacin is needed for healthy body tissues. Effective in treating and preventing pellagra.

Iron is the mineral used in enrichment. Essential for making good, red blood and in preventing nutritional anemia.

How Is White Bread Enriched?

Several methods may be used. In one, bakers use enriched white flour—flour which has been enriched at the mill according to federal definitions and standards of identity or state law.



Most bakers in the United States use a tablet or wafer. One of these contains enough thiamine, riboflavin, niacin and iron to enrich 100 lbs. of unenriched white flour—sufficient to produce 155 lbs. of white bread.

One popular form of wafer is known as "Square." Shown above in actual size, the "Square" wafer has many advantages for the baker.

Square wafers are distributed in two types by leading yeast companies throughout the United States:

Type A—for use in bread formulas requiring 3% or more non-fat milk solids.

Type B—for use in bread formulas requiring less than 3% non-fat milk solids.

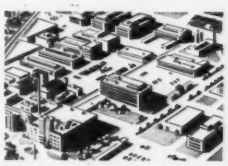
How to Identify Enriched Bread

You can't tell enriched bread by its appearance or taste. If you live in one of the 27 states having laws requiring white flour and bread to be enriched you can assume you're getting these nutritionally improved products. But all packages of enriched flour, and all wrapped enriched white bread, must show the word "enriched." Look also for a declaration on your bread wrapper similar to this:

> 8 ounces of this enriched bread supply you with at least the following amounts of your minimum daily requirements for these essential food substances: Thiamine (vitamin B_1) 55%; Riboflavin (vitamin B_2) 17.5%; Niacin (another "B" vitamin) 5 milligrams; Iron 40%.

Wherever you go, insist on bread enriched with vitamins and iron for better nutrition—for better health—for better well-being.

Vitamins Are Made



While vitamins occur naturally in foods, most vitamins used in food processing are manufactured through the marvels of chemistry and engineering. At the huge Roche Park plant of Hoffmann-La Roche they are manufactured *by the tons*. Using amazingly complex processes with scientific production controls and intricate equipment, the Roche people produce pure vitamins that are equal chemically and in biological activity to Nature's own. So efficient are these operations that the vitamins are sold at lower prices than if they were extracted from natural sources.

This article is published as a service to the baking industry by a pioneer in enrichment—Hoffmann-La Roche Inc. Reprints are available on request without charge. Write to the Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, New Jersey.

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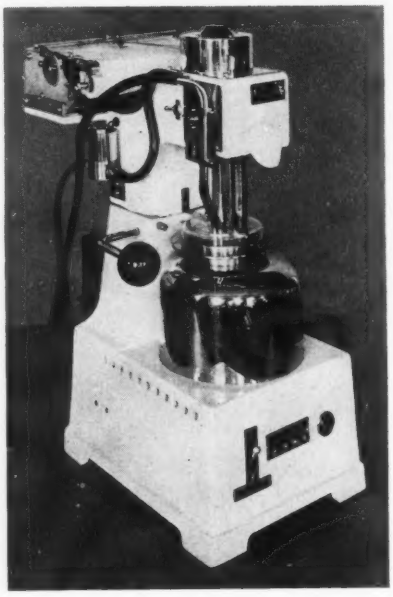

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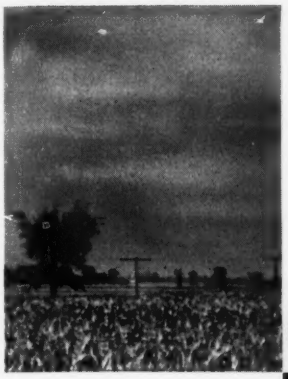

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Congratulations on an Important Occasion

Merck & Co., Inc., extends congratulations to the American Association of Cereal Chemists on the launching of their new publication, *Cereal Science Today.*

FIRST IN VITAMINS

MERCK & CO., INC. RAHWAY, NEW JERSEY

Editorial

THE INTRODUCTION of any new publication into the already crowded field of professional journals merits the most careful consideration by its publisher. Will the new periodical fill a *real* need in an area not now being served by others? Will it command a sufficiently large audience to ensure financial solvency in these days of ever increasing publishing costs? For the past several years there has been an openly expressed desire on the part of A.A.C.C. members for an applied journal covering current laboratory developments in the fields of cereal chemistry and cereal technology. This is a very specialized area of biochemistry and one that is growing increasingly important as the world's population expands. Production aspects of the cereal and cereal by-products industry are already covered by many excellent business and professional journals. But unfortunately there has been a lack of emphasis on the vital developmental work being done in the laboratory by the chemist and technologist. The phenomenal popularity of consumer mixes and the success of formulated feeds graphically illustrate the importance of the laboratory in today's complex civilization. Management has begun to realize the significant contribution the chemist can make toward diversification and the development of new markets.

Cereal Science Today will highlight the significant developments taking place in government, academic, and industrial laboratories for the benefit of both the chemist and the nonchemist. It hopes to do this by: (1) presenting the chemist and technologist with technical information concerning everyday laboratory problems and developments, such as new analytical methods, up-to-date control techniques, laboratory shortcuts, etc.; and (2) presenting the nonchemist (members of management, sales, production, etc.) with a comprehensive survey of technical developments, written in an informal style. To both of these groups will be aimed such subjects as packaging, advertising, technical service — along with news of people, products, and services of interest to the industry. To help accomplish these aims, the broad subject field of cereal chemistry has been divided into six convenient areas or departments, each edited by one or more specialists. Scientific and technological progress throughout the world will be covered by individuals working in the various countries who will serve as Corresponding Editors.

The editors have planned many features for the months ahead and new topics will be added to meet the needs of our readers. You are invited to communicate with us, offering criticisms and making suggestions for forthcoming issues.

W. F. GEDDES R. J. TARLETON

INTRODUCING

the authors

• WILLIAM H. CATHCART

Dr. Cathcart, current president of the American Association of Cereal Chemists, received the A.B. degree from Indiana University in 1933, the A.M. degree in 1934 and the Ph.D. degree (in chemistry) from New York University in 1936. He directed the laboratory of the American Institute of Baking from 1936 to 1941. Since 1941 he has been director of research for the National Bakery Division of the Great Atlantic & Pacific Tea Co. and is a director of the National Bakery Division.

Dr. Cathcart has contributed numerous scientific papers and technical

articles to various scientific journals, including *Cereal Chemistry* and *Transactions*. He is the author of Chapter 26, "Baking and bakery products," and Chapter 40, "The production of bread and bakery products" in *The Chemistry and Technology of Food and Food Products*, edited by M. B. Jacobs (Interscience: 1951); and of Chapter 14, "Bakery refrigeration," in *Refrigerating Data Book* (A.S.R.E., now in revision).

• REUBEN POMERANTZ

Captain Pomerantz, born August 10, 1921, at Hartford, Conn., was graduated from Weaver High School at Hartford in 1939 and from Trinity College, Hartford, in 1943, with a Bachelor of Science degree in chemistry. Having entered the Army Air Force in 1942, he received an honorable discharge in 1943 to enter the United States Military Academy.

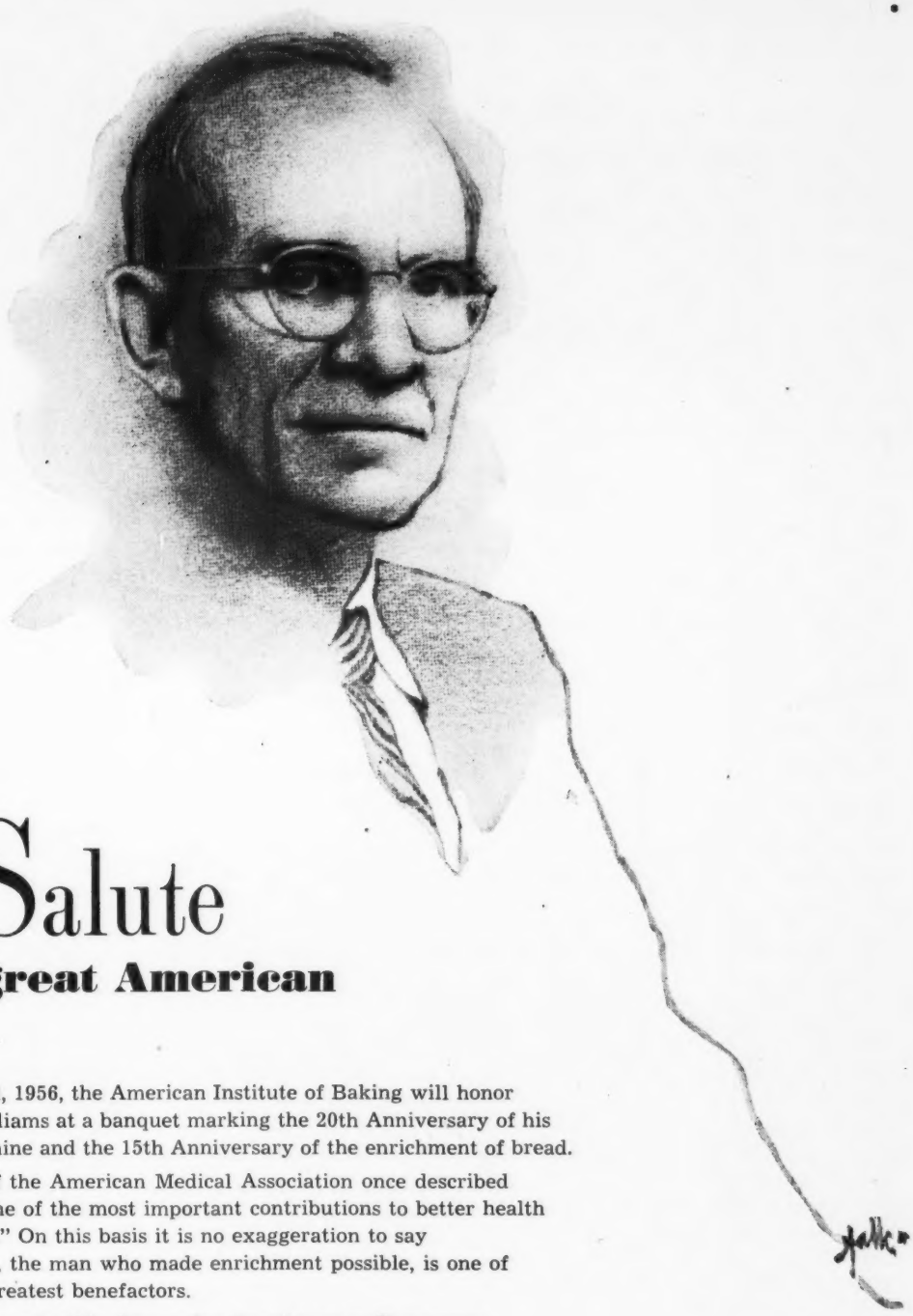
Upon graduation from West Point in 1946, he attended service schools at Fort Benning, Georgia, and Fort Lee, Virginia. In 1948 he was assigned to duty with the Army Quartermaster in the Canal Zone. After completing his overseas tour in 1951, Captain Pomerantz attended M.I.T., where he obtained the M.S. degree in food technology in 1953. He was then assigned to the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois, as Radiation Preservation Officer. In his present capacity as Military Adviser to the Commandant on Radiation Preservation, he assists in planning, coordination, and direction of research and development, with the over-all objective of preserving food products by radiation. Captain Pomerantz recently was awarded the Army Commendation Medal for meritorious service in his present assignment.

• REGINALD C. SHERWOOD

Dr. Sherwood is vice-president and technical director of Sterwin Chemicals Inc., New York 18, N. Y. Dr. Sherwood has been technical director of Sterwin since 1946 when he joined the company. He supervises research and development of new products, production, control, and technical service. During World War II he was assistant chief, Civilian Food Requirements Branch, War Foods Administration, Washington, D. C. Previously he was associated from 1929

to 1943 with General Mills, Inc., Minneapolis, as divisional vice-president and general manager of research laboratories. Before joining General Mills' staff he was director of the Minnesota State Experimental Flour Mill for five years.

Dr. Sherwood has published over 60 technical articles in scientific journals on cereal chemistry and vitamin enrichment. He received B.S., M.S., and Ph.G. degrees from South Dakota State College and the Ph.D. degree from the University of Minnesota.



Salute

to a great American

On April 23rd, 1956, the American Institute of Baking will honor Dr. Robert R. Williams at a banquet marking the 20th Anniversary of his synthesis of thiamine and the 15th Anniversary of the enrichment of bread.

A President of the American Medical Association once described enrichment as "one of the most important contributions to better health in our generation." On this basis it is no exaggeration to say that Dr. Williams, the man who made enrichment possible, is one of his generation's greatest benefactors.

In an age when scientific discoveries threaten as well as serve mankind, it is a special pleasure to pay tribute to a scientist whose research and life have been devoted to making his fellow man both healthier and happier.

We deem it an honor and privilege to be an allied member of the industry that supported and implemented this dedicated fighter in his world-wide war against "hidden" hunger.

We are proud to salute Dr. Robert R. Williams as a truly great American.

THE FLEISCHMANN DIVISION STANDARD BRANDS INCORPORATED

WHAT CAN WE EXPECT FROM Frozen Bakery Products?

by William H. Cathcart*

IN THE BAKING industry, as well as in other fields of human endeavor, developments tend to follow a spiral or circular path rather than a straight line. Processes that at first glance seem new may, on closer study, be found to have been devised in principle years ago. An example of this is modern quick breadmaking. A breadmaking machine patented by Robinson and Lee in 1850 and put into use in Glasgow, Scotland, is similar in operation to some of the newer processes of today. Some advantages claimed for the machine were that it improved the working conditions of journeyman bakers; the bread was unfermented and so would not ferment in the stomach after being eaten; and the dough was not mixed with naked arms or feet! A century later a process appears, with refinements of course, that is much the same even though emphasis is not placed on the same "advantages."

The freezing of bakery products is new only in today's commercial application. After our early work on frozen bread, reports came from Alaska that for some time it had been accepted practice to leave bread out in the intense cold until wanted for eating. Lumber camps in the far north froze a winter's supply of bread at a time, and many a housewife in years past baked up a batch of mince pies and froze them in the woodshed, to be available for use on short notice.

In many ways bakery products are better adapted to freezing than some items that are now being frozen in large quantities. Enzyme systems in fruits and vegetables must be inactivated by blanching or other treatment before freezing. Bakery products, however, either baked or unbaked, require no treatments, processes, or techniques foreign to bakery make-up practice to prepare them for freezing. This does not mean that bakery products in all forms can be frozen satisfactorily. It is still necessary to find out what products are best suited for freezing; whether they should be frozen baked or unbaked; and how they should be packaged, frozen, and stored to maintain good quality.

In addition, the baker must remember that when he starts freezing bakery products commercially he is proceeding from a product with a few days' shelf life to one that might be kept for several months. This introduces the possibility of oxidative changes in the product even though it is kept at very low temperatures. These reactions have a great deal to do with the length of time that a product may remain salable, as is illustrated in the work reported below on the freezing of bread.

Methods of Following Bread Staling

In any study of bread staling, and of freezing as a means of its retardation, methods of determining staling are important. Many methods have been outlined to determine this change; briefly, they are:

1. Swelling of the crumb in water.
2. Crumbliness of crumb.
3. Viscosity of the crumb in water.
4. Amount of soluble starch (B-fraction).
5. X-ray patterns.
6. Opaqueness of crumb.
7. Firmness or compressibility of crumb.
8. Taste panel.

All of these methods, except the last two, measure only the change in the starch that takes place during staling. They do not measure the effect of the ingredients on keeping the crumb soft, which may be noticed by a taste panel or by firmness or compressibility measurements. There is little doubt that the best method for practical purposes is the taste panel. However, it is not always practical to perform tests by means of a taste panel, and thus the next-best test must be used. The closest approach to the taste panel is firmness or compressibility measurements. Tests which measure only the change in the starch are not to be eliminated, however, because any treatment which prevents the staling change in the starch from taking place will positively keep bread fresh and will undoubtedly be confirmed by the firmness or compressibility measurements, and/or by a taste panel. Thus, some tests that measure only changes in starch are useful research tools. The staling of the bread discussed here was measured by swelling of the crumb in water, by firmness and compressibility measurements, and/or by a taste panel.

There are several instruments which can be used to measure firmness or compressibility of bread crumb. A modified A.S.T.M. Penetrometer measures how far a 3-cm. disk under a load of 215 g. will depress the crumb in 10 seconds. The Baker Compressimeter (1), also available commercially, is an excellent instrument for making these measurements. Figure 1 shows a modified Bloom Gelometer which has a circular plunger 1 in. in diameter and measures the weight required to depress the

* The Great Atlantic and Pacific Tea Co., National Bakery Division, New York 17, N. Y.

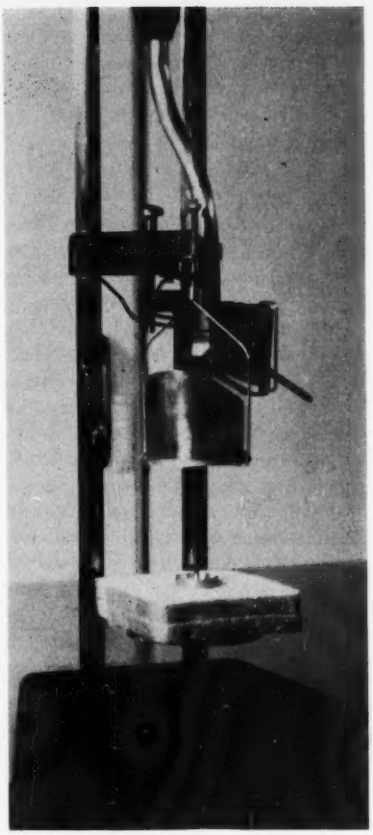


Fig. 1. Modified Bloom Gelometer used for measuring firmness of bread crumb. Measures weight required to depress bread crumb to 4-mm. depth.

crumb 4 mm. We used this instrument in most of our compressibility measurements. Other instruments have been developed for measuring firmness or compressibility of bread crumb, most of which have been "home-made."

In determining the swelling of bread crumb in water the procedure (1) briefly is as follows:

> Ten grams of bread crumb together with water saturated with toluene are passed through a brass-framed 200-mesh sieve 5 in. in diameter. The washings passed through the sieve are transferred to a 250-cc. graduate and diluted to the mark. The graduates are allowed to stand 24 hours. Readings are made of the amount of sediment — the greater the amount, the fresher the bread. A sediment of approximately 48 cc. would represent fresh bread and a sediment of about 35 cc. would indicate staleness.

Freezing of Baked Bread

Bread was experimentally frozen soon after the turn of the century. The most extensive work, preceding our current research, which began at the American Institute of Baking, was carried on by J. R. Katz (8) of Amsterdam, Holland. Katz' problem was to find a method for keeping bread fresh overnight; thus, he was not particularly concerned with preserving its eating quality for days or months. Katz found that staling accelerates as temperature is decreased; at the temperature of liquid air and at 140°F. and above, bread remains fresh; and as the temperature is lowered from 140°F., bread stales — the lower the temperature the greater the rate of staling, reaching a maximum at 26.6°F. This was the freezing point of the bread Katz was using. As the temperature was reduced below this point, the rate of staling decreased rapidly.

Confirming Katz' work, Edelmann and Cathcart (6) observed a difference in the rate of staling of modern white pan bread at 82.4° and 50°F. Their work showed that bread stored at 50°F. for 48 hours was firmer than bread stored at 82.4°F. for 96 hours (see Fig. 2). *This indicates the need to prevent chilling from the time the bread is baked until it is consumed.* It also indicates that the consumer who wants soft bread should never put it in a refrigerator.

Rate of Freezing Bread Wrapped in Waxed Paper. Our original experiments (5) with frozen bread were carried out at two temperatures, —7.6° and —31°F. Loaves weighing 1¼ lb. each were wrapped in waxed paper and frozen 8 hours after baking. During freezing they were spread out on racks, in still air. When the bread was to be tested it was thawed out in the wrapper. About 4 hours were required to bring it to room temperature. Comparisons were made with fresh bread 12 hours old, to correspond to total time of frozen bread out of the freezer.

In early experiments it was noted that freezing time at —31°F. was less than one-half that required at —7.6°F. Further comparisons concerning these original freezing experiments are discussed under the next subheading.

Swelling Power and Compressibility Readings. The bread was tested by a group of judges and also by an expert scorer. In addition, swelling power and compressibility tests were made.

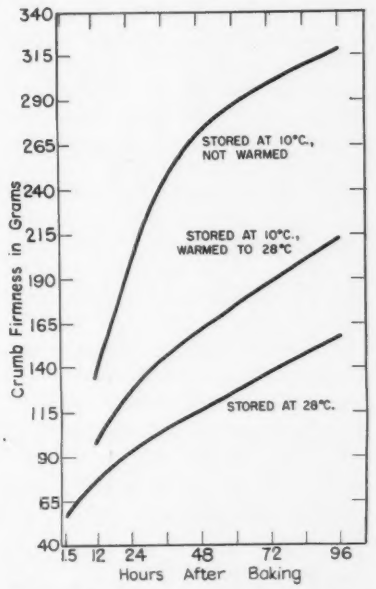


Fig. 2. Rate of firming of white bread held at 82.4°F. and 50°F.

Table I shows swelling power and compressibility of breads frozen at the two different temperatures. Note the comparative figures on fresh bread 12 hours old. These results

TABLE I[a]

COMMERCIAL WRAPPED UNSLICED WHITE BREAD FROZEN FOR DIFFERENT PERIODS[b]

TIME IN FREEZER	FREEZER TEMPERATURE —7.6° F.		FREEZER TEMPERATURE —31° F.	
	Swelling Power	Compressibility	Swelling Power	Compressibility
days	*cc.*	*cm.*	*cc.*	*cm.*
1	34	4.0	40	4.0
4	34	2.1	37	2.4
8	36	2.1	36	3.7
19	32	2.8	32	2.8
40	33	1.7	36	3.3
60	36	1.8	39	4.6
110	37	...	38	...

[a] Reprinted from Cathcart, W. H., and Luber, S. V., Ind. Eng. Chem. 31: 362 (1939), with permission.
[b] For comparison: Unfrozen bread 12 hours old: Swelling power, 40 cc.; compressibility, 4.0 cm.

show that bread frozen at the lower temperature is fresher after 1 day and at the end of 40 days than that frozen at the higher temperature. In addition it should be noted that there is a tendency, insofar as swelling power and compressibility results go, for bread frozen at the lower temperature to refreshen beginning at about 40 days. However, in view of the opinions of the judges, the limiting factor on the time that the bread remains good in frozen storage was the developing of an off-aroma. According to these tests, the bread remained good for 20 days and salable for approximately 40 days at —7.6°F. At —31°F. it had much better keeping quality and was considered salable after 110 days in the freezer.

Rate of Firming of Fresh Bread and Frozen Bread. Figure 3 illustrates the firming rate of fresh unfrozen bread and bread that was frozen in moving air at —5°F. for 20 hours and then thawed. It will be noted from the two solid curves that the rate of firming for these breads is about the same. The frozen bread firmed somewhat during cooling and also during defrosting. Consequently, there is some doubt as to where the curve should be started for the frozen bread. If we move the curve over to the same starting time interval as the fresh unfrozen bread (dotted line), the frozen bread shows greater initial firmness, but the slope of the curve indicates that it is firming at a slightly slower rate than the fresh unfrozen bread. Perhaps it would be more feasible to move the starting point of the frozen bread to a point on the abscissa between the two starting points now shown in the graph of Fig. 3, in order to compensate for the elapsed time interval of freezing and defrosting.

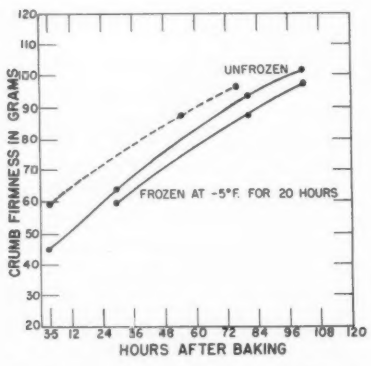


Fig. 3. Comparison of firming rates between fresh unfrozen bread and bread frozen at —5°F. in moving air. Dotted line represents hypothetical curve for frozen bread at same starting time as unfrozen bread.

Canning of Bread. Baking and subsequent canning greatly increased the keeping time of bread frozen at —7.6°F. The bread was canned 3 hours after baking and immediately placed in the freezer. Bread sealed at normal atmospheric pressure remained salable for approximately one year, and that sealed in vacuum not only remained salable but was quite similar to fresh bread for this same period.

Rapid Freezing of Bread. Since bread stales faster at or near its freezing point, it is important to pass this point as quickly as possible in both freezing and defrosting of the product. Figure 4 shows the freezing rate of wrapped and unwrapped bread at —22°C. (—7.6°F.) and —35°C. (—31°F.) in a forced-air tunnel. It can readily be seen that freezing was fastest in the unwrapped product at the lower temperature. It is also clearly demonstrated how any insulating material will slow up the rate of freezing. Needless to say, the bread frozen at the fastest rate was superior in quality.

Conclusion of Bread-Freezing Experiments. Thus, we can conclude that all types of baked breads freeze well provided they are wrapped sufficiently well to prevent moisture loss but not so well that they are insulated, and provided they are frozen and defrosted so as to pass the freezing point rapidly.

Other Yeast-Raised Products

Yeast-raised products other than bread can be frozen with the same success as bread, either in the finished baked form or in the "brown-'n-serve" (partially baked) form. In baked form these yeast-raised products can be kept in good condition in storage for a time corresponding to that of bread, provided the necessary precautions for wrapping, methods of freezing, storage temperatures, and defrosting are followed as outlined in the bread experiments above. However, since these yeast-raised products are generally smaller units than bread, there seems to be a desire to freeze them in the dough stage, particularly after they have been fermented, made up, and proofed. Since little success has been attained by freezing in this form for any length of time, we have conducted experiments to find out why, and if possible to find a method which would allow them to be successfully frozen (7). Doughs of this type are very sensitive to rate of freezing, storage temperature, storage time,

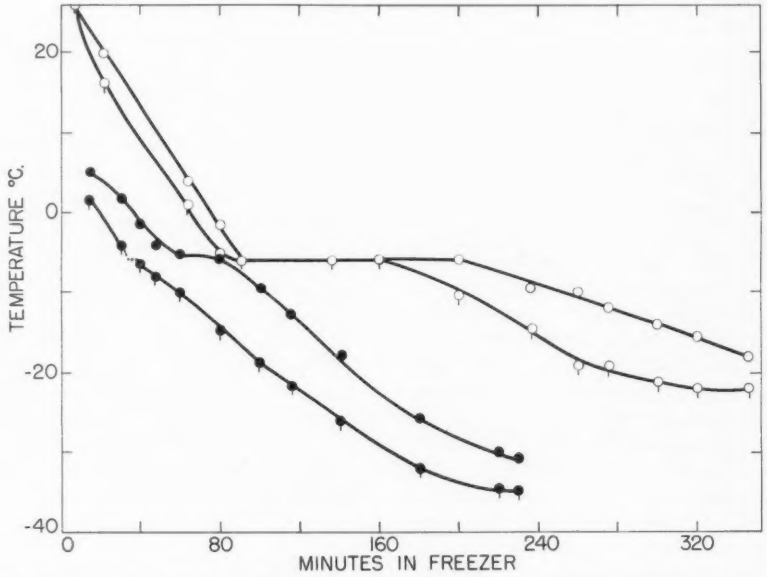


Fig. 4. Rate of cooling of bread in forced-air tunnel. At —22°C. (—7.6°F.): Open circles, wax-wrapped; open circles with suspended bar, unwrapped. At —35°C. (—31°F.): Closed circles, wax-wrapped; closed circles with suspended bar, unwrapped. (Reprinted from Cathcart, W. H. Cereal Chem. 18: 771 (1941), with permission.)

and time fermented prior to freezing. Most of our work has been concentrated on dinner rolls; however, the results apply equally well to other yeast-raised products.

Freezing Rate and Its Effect on Panned Rolls. The results of our experiments in freezing panned roll dough (7) somewhat paralleled those with bread, in that superiority of the product increased with the rate of freezing. Freezing rates were 0°F. and —10°F., and in some cases part of the packaging material was omitted for minimum insulating effect. At the lower temperature, —10°F., rolls froze in approximately 30 minutes' less time than at 0°F. The freezing temperature of these rolls was approximately 15.8°F. Rolls wrapped only in cellophane froze in approximately one-half the time required for those frozen in a chipboard box. *This emphasizes the advantage of using as little packaging as possible during freezing.*

Table II shows the effect of freezing rate on rolls frozen at the different temperatures and in different ways after 75 days' storage. The effect of the freezing is demonstrated by the time required to thaw and pan-proof the products. The most satisfactory baked product resulted from the roll dough frozen at the fastest rate. Although yeast activity in the quickest-frozen product had greatly diminished after this long storage interval, the surviving yeast cells did produce a moderately satisfactory product following an extended thaw and pan-proof interval.

Effect of Fermentation. Table III compares unfermented and fermented roll doughs frozen on quick-freezing plates and stored at —10°F. Freezing rates were identical for these doughs, the only difference being their condition when frozen: unfermented dough was frozen immediately after mixing and panning; the other doughs were fermented for 3 hours and then panned and frozen. It is apparent that the fermented doughs did not hold up under freezing as well as the unfermented doughs. A satisfactory product could be obtained with the unfermented dough after a storage time up to 21 days. Yeast activity began to decrease noticeably at this time, falling off sharply in fermented roll doughs after 7 days' storage. Evidently the condition of the yeast in a fermented dough is such that it cannot withstand freezing storage as well as it can in a dough that is not fermented before freezing.

TABLE II[a]

EFFECT OF COOLING RATE ON UNFERMENTED ROLL DOUGHS FROZEN AND STORED 75 DAYS

MODIFICATION	THAW AND PAN PROOF INTERNAL		VOLUME
	hours	*minutes*	*cc.*
Pans of roll doughs placed in cardboard box in cabinet at —10°F.	3	27	1115
Pans of roll doughs placed on metal rack in cabinet at —10°F.	3	2	1295
Pans of roll doughs placed on metal rack in cabinet at 0°F.	3	18	1215
Control No. 1—rolls not frozen	1	35[b]	1325
Control No. 2—rolls not frozen	1	35[b]	1240

[a] Reprinted from Godkin, W. J., and Cathcart, W. H. Food Technol. *3:* 139 (1949), with permission.
[b] Pan proof.

TABLE III[a]

COMPARISON OF UNFERMENTED AND FERMENTED ROLL DOUGHS STORED AT —10°F.

STORAGE	THAW AND PAN PROOF INTERVAL		VOLUME AFTER BAKING		YEAST CELLS (IN MILLIONS) PER G. OF DOUGH: STANDARD PLATE COUNT 86°F. FOR 72 HR. AT 85% R. H.	
	Unfermented	Fermented	Unfermented	Fermented	Unfermented	Fermented
days	*min.*	*min.*	*cc.*	*cc.*		
1	107	93	1210	1380	290	240
2	95	105	1295	1295	270	201
3	90	109	1215	1330	259	215
4	95	100	1280	1295	207	185
7	95	102	1285	1235	264	187
11	115	135	1295	1150	210	48
14	112	135	1215	1225	200	32
21	110	206	1285	1165	19	20
28	128	300	1270	1195	12	56
Controls[b]	95[c]	55[c]	1325	1275	306	251

[a] Reprinted from Godkin, W. J., and Cathcart, W. H. Food Technol. *3:* 139 (1949), with permission.
[b] Not frozen.
[c] Pan proof only.

Conclusion of Roll Freezing. Thus, all yeast-raised products should be frozen after baking or in the "brown-'n-serve" form unless only a short storage period (1 to 2 weeks) is desired. Rolls shown in Fig. 5 (4) were frozen for 1 month at —10°F.

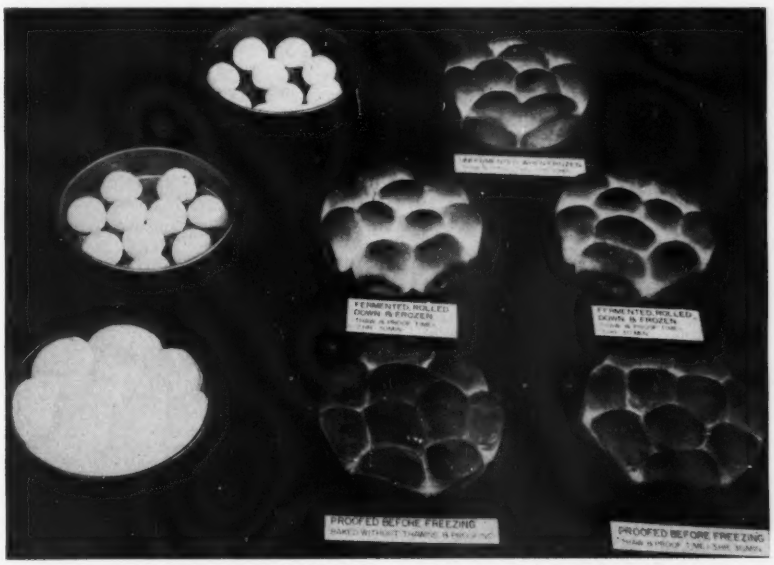


Fig. 5. Frozen roll doughs, stored at —10°F. for 1 month before baking. Rolls at left in each row are in the unbaked and frozen condition. The yeast was most active in the rolls which were unfermented before freezing (top row) and made the best baked product. Top row: right, unfermented when frozen — thaw and proof time 2 hours 30 minutes. Center row: middle, fermented, rolled down, and frozen — thaw and proof time 2 hours 30 minutes; right, fermented, rolled down, and frozen — thaw and proof time 2 hours 30 minutes. Bottom row: middle, proofed before freezing, baked without thawing and proofing; right, proofed before freezing — thaw and proof time 3 hours 30 minutes. (Reprinted from Cathcart, W. H. Food Technol. 4: 209-218 (1950), with permission.)

Pies, Cakes, and Cookies

Of the various bakery products which may be frozen, the freezing and frozen storage of pies, cakes, and cookies is economically more feasible because of their relatively higher price. They have longer life in the freezer than bread products, and are not so likely to develop off-flavors, nor so sensitive to freezing rate or storage temperature as are yeast-raised products.

Pies. Pies, with the exception of cream and meringue pies, can be quick-frozen either before or after baking. We (2) have frozen baked and unbaked pies at —25°, —15°, and —8°F. and have held them in frozen storage at —15° and —8°F. Unbaked pies frozen at —25°F. in a plate freezer and stored at —15°F. were in satisfactory condition 9 months after freezing. Baked pies frozen and stored at the same temperatures were unsatisfactory after 2 to 3 weeks, unless the filling was reheated to the boiling point. Organoleptic methods were used exclusively in determining quality in all frozen-pie experiments.

Figure 6 shows the freezing rate of two cherry pies frozen under different packaging conditions and at freezing temperatures of —5° and —15°F. The curves illustrate dramatically the insulating effect of the corrugated carton. Although the pie in a heavy corrugated carton was subjected to a lower temperature than the one in an individual pie box, its freezing rate was considerably slower.

Fillings break down in both unbaked and baked frozen pies, but when fillings of frozen pies are heated to the boiling point the gel is brought back to its original state. The storage life of baked pies can be increased to that of unbaked pies if they are thoroughly heated before being served. It is obvious to the consumer that an unbaked frozen pie must be baked before it is eaten, but a baked frozen pie already having a baked crust may be merely allowed to defrost, or be given a minimum of heating time in order to avoid coloring the crust too much. Because of this, pies which are frozen unbaked are less likely to disappoint the customer. Pies treated in different manners are shown in Fig. 7.

Frozen pies can be baked immediately upon removal from frozen storage, or after defrosting. If placed in the oven while in the frozen state they require a longer baking period. We found that 65 minutes at 360°F. were required to bake frozen pies immediately out of frozen storage, whereas pies defrosted at room temperature (approximately 75°F.) for 4 hours before baking required 50 minutes at 360°F. These results apply to two-crust pies. Lattice-top pies require slightly different handling, because the frozen filling tends to prevent the narrow lattice-strips of dough from coloring evenly. Such pies are better if defrosted before baking.

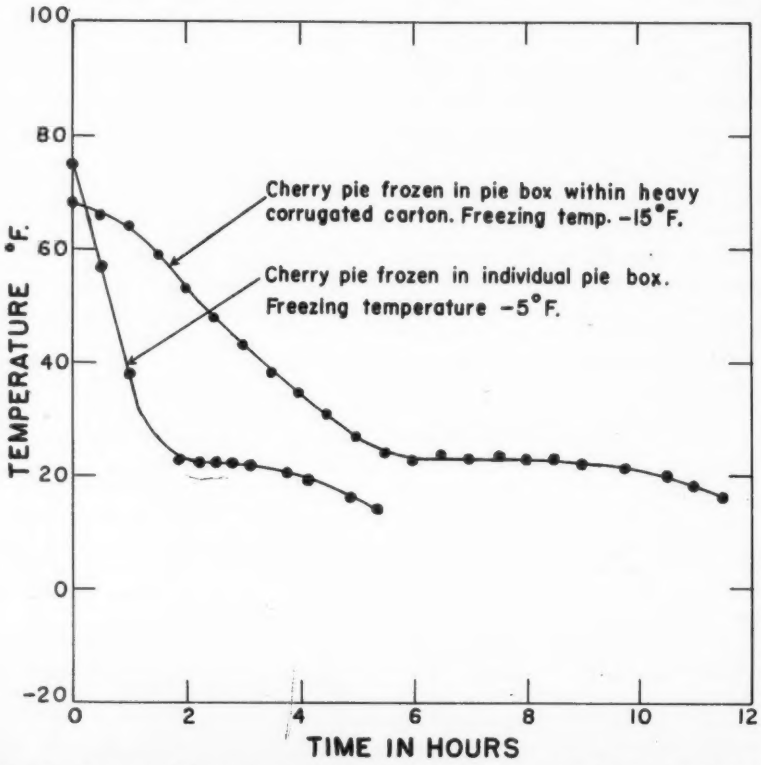


Fig. 6. Freezing rates of cherry pie at different freezing temperatures and under varied packaging conditions.

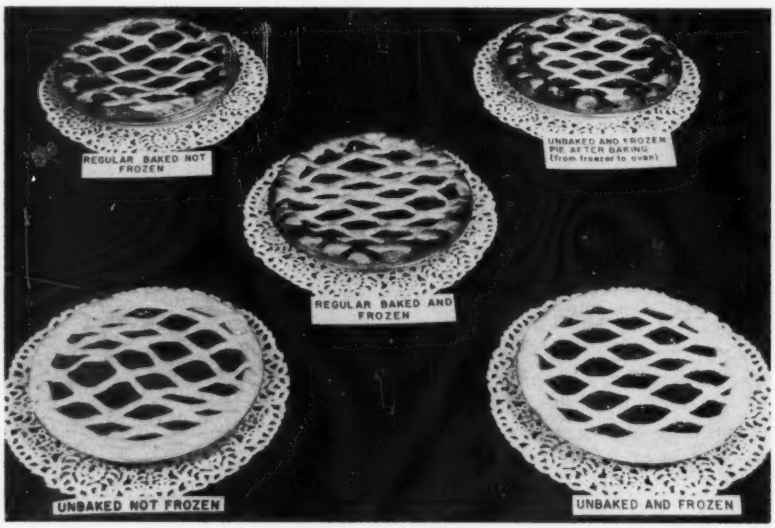

REGULAR BAKED NOT FROZEN
UNBAKED AND FROZEN PIE AFTER BAKING (from freezer to oven)
REGULAR BAKED AND FROZEN
UNBAKED NOT FROZEN
UNBAKED AND FROZEN

Fig. 7. Unbaked and baked frozen pies.

It is estimated that commercially baked pies account for only 10% of those eaten. Thus, it appears that in frozen pies, and especially frozen unbaked pies, the baker has an opportunity to capture a larger share of the pie market, since he can make it so easy for the housewife to serve freshly baked pies.

Cakes. If wrapped properly to prevent dehydration, both iced and uniced baked cakes can be successfully frozen and will remain in good condition in frozen storage for more than a year. We (2) have quick-frozen iced cakes at —25°F. and stored them at —15°F.; fourteen months after freezing they were in satisfactory condition. Figure 8 illustrates some of these cakes. Iced and uniced cakes frozen and stored (—8°F.) were in very good condition after 4 months in the freezer, at which time the tests were discontinued. We have found that temperatures used for freezing and storing cake are not so critical as for other bakery products. With iced cakes, icings of the boiled type tend to become chewy after long frozen storage. Pudding-type icings or fillings are unsatisfactory because the puddings break down during frozen storage, and as an iced cake cannot be reheated, the pudding cannot be brought back to its original state. Other icings, such as fudge and cream types, withstand frozen storage very well.

Some experiments have been made on unbaked cake batters, frozen and stored at 0°F. In general, batters do not keep as well as baked cakes, but, when thawed prior to baking they gave satisfactory cakes after 3 to 4 months of storage.

Cookies. Cookies lend themselves well to freezing and frozen storage, whether frozen before or after baking. Baked and unbaked cookies frozen at —25° and stored at —15°F. for as long as 14 months were judged to be as good as cookies a few hours out of the oven (2). Unbaked cookies may be sold individually shaped by the baker and needing no defrosting, or as a roll of frozen dough which can be shaped after defrosting by the consumer. Because many cookies require unusual cutters or in some cases ingredients not usually found in the average home, the baker has an unusual opportunity to sell the consumer a skillfully made product for baking in her own home.

Conclusion of Freezing of Pies, Cakes, and Cookies. Most types of pies can be frozen and stored successfully in this condition. The fillings of frozen baked pies must be reheated to the boiling point before serving, in order to reconstitute the gel. With few exceptions, baked cakes can be frozen and stored without any trouble. Freezing and storing of cakes containing a boiled-type or pudding-type filling is not recommended. Cake batters can be frozen and stored in this condition successfully for shorter periods of time, provided they are thawed before baking. No problem is anticipated with the freezing and frozen storage of cookies, either in the baked or unbaked condition.

Commercial Freezing

The baker who is considering the freezing of bakery products will undoubtedly have one or both of two plans in mind: He will freeze merely to get more economical operation of his bakery without retailing frozen products, expecting the cost of freezing to be more than offset by a better-balanced production schedule, by utilization of slack production time, by longer runs without changeovers, by less production at premium rates on overtime hours, holidays, and nights, and/or by fewer stale returns; his products will reach his customers fully baked or in the "brown-'n'-serve" state. On the other hand, selling frozen products may be to his advantage; if so, he will also realize the benefits noted above.

Although the consumer may be extremely tolerant as to quality in her own home-freezing efforts, she demands top quality in the frozen products that she buys, regardless of how long she may hold them in the freezer. Any baker who anticipates good reception for his frozen products is heading for disappointment if they are produced haphazardly and are mediocre in quality.

To assure top quality, bakery products should be frozen as soon as they are made up, if unbaked, and if baked, as soon as they are cooled to normal wrapping temperature. They must be wrapped, to prevent moisture loss and to give protection against mechanical damage in handling. Ordinary cellophane is not suitable; type MSAT-87 should be used. Polythene and waxed paper are also satisfactory. There should be as little air space as possible between product and wrapper. In some cases mechanical protection with a heavy overwrap or with a cardboard pastry box will be necessary, but since these materials are good insulators and will retard the rate of freezing, it is preferable to apply them after freezing is complete.

Packing bakery products at room temperature in shipping cartons and freezing them in a room held at ordinary frozen storage temperature is unsatisfactory. The insulating effect of the carton, the tight pack of the contents, and the lack of air movement all tend to give a very slow freeze and to hold the product too long at the freezing point. Freez-

Fig. 8. Baked frozen and unfrozen cakes.

ing should be done in a tunnel or a plate freezer at —20°F. or lower. The greater the differential between the freezing point of the product and the temperature of the freezer, the quicker will be the freeze. The capacity of the freezer is very important. Too small a unit may give freezing times that are too long and may necessitate holding products on racks at room temperature when they should be undergoing freezing. A baker should know what his hourly load is going to be before he gets his freezer and should be sure that it has ample capacity.

After freezing, products should be given additional wraps when necessary and then should be packed into shipping cartons and immediately put into storage at —10°F.

The above is illustrated by the following experiments showing the effect of different rates of freezing and defrosting on freshness of white bread under present processing methods and formulas.

One-pound cellophane-wrapped sliced loaves 5 hours out of the oven were packaged in three corrugated shipping cartons 23 inches by 28 inches by 5 inches, each containing 15 loaves. The cartons were piled one on top of the other in the freezer with moving air. Thermocouples were placed in the centers of loaves at a corner of the lower carton (No. 1), the center of the top carton (No. 2), and the center of the middle carton (No. 4). Other loaves were frozen simultaneously in moving air outside of the cartons (No. 3) (see Fig. 9). Freezer temperature was —10°F. Control loaves were held at room temperature.

Figure 9 shows the rate of freezing of the differently placed loaves. Freezing point of the bread was 16°F. The individually frozen loaf (No. 3) reached freezing point in 3 hours and freezer temperature in 8 hours. The loaves in the cartons did not drop to freezer temperature in the 48-hour period. The center loaf in the middle carton (No. 4) did not reach freezing point until 43 hours, and the minimum temperature reached was 7°F.

After being in the freezer 48 hours, the three cartons were removed and piled at room temperature, 80°F., in the same order in which they had

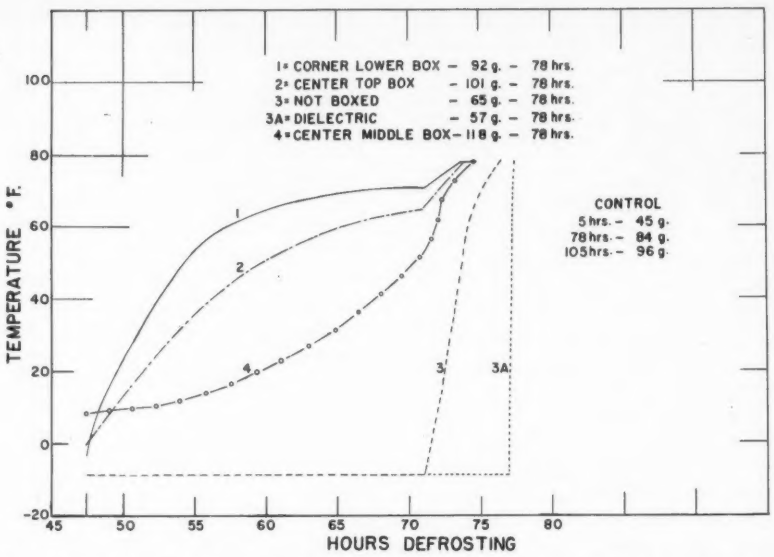

1= CORNER LOWER BOX — 92 g. — 78 hrs.
2= CENTER TOP BOX — 101 g. — 78 hrs.
3= NOT BOXED — 65 g. — 78 hrs.
3A= DIELECTRIC — 57 g. — 78 hrs.
4= CENTER MIDDLE BOX — 118 g. — 78 hrs.
CONTROL
5 hrs. — 45 g.
78 hrs. — 84 g.
105 hrs. — 96 g.
TEMPERATURE °F.
HOURS DEFROSTING

Fig. 9. Effect of packaging insulation and placement position of loaves on the freezing rate of bread in moving air.

been frozen (see Fig. 10). Twenty-four hours later (72 hours in all) the loaves were not up to room temperature, so they were removed from the cartons and defrosting was completed. At the same time, loaves that were frozen individually in moving air were removed from the freezer and defrosted, some by means of intermittent 10-second applications of dielectric heat (No. 3A) and others not so rapidly, at room temperature (No. 3). Crumb firmness was determined on all loaves.

Of the loaves in the cartons, the one that froze slowest defrosted slowest (No. 4). The loaf individually defrosted at room temperature (No. 3) defrosted in 5 hours, and the one on which intermittent electronic heat was used (No. 3A) was brought to room temperature in 30 minutes.

Crumb firmness measurements show that all loaves frozen and defrosted in the cartons had firmer crumb at 78 hours after baking than did control loaves of the same age stored at room temperature (see Fig. 10). The firmness varied directly with the rate of freezing and defrosting. On the other hand, loaves that were frozen and defrosted rapidly

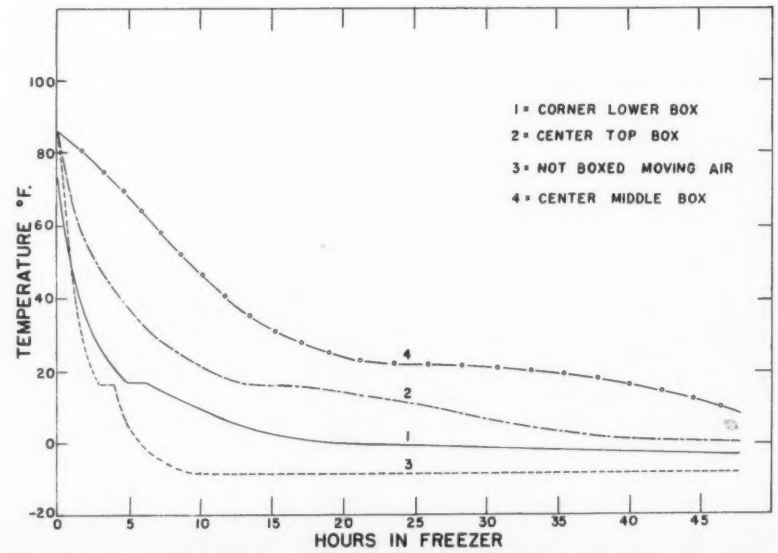


Fig. 10. Variation of defrosting rates of bread loaves from Fig. 9 and effect on firmness. Figures in grams are crumb firmness measurements at listed time interval after baking.

had softer crumb than the control loaves after 78 hours.

Conclusion of Commercial Freezing of Bread. These tests indicate that freezing of bread (unless frozen and defrosted rapidly) is of little value in maintaining freshness unless the bread is to be held longer than 78 hours. The results emphasize a very important point: the necessity of going through the cool range rapidly in defrosting as well as in freezing.

Future Outlook

What are the possibilities of the increased use of freezing by the baker? It seems to us that experience in other fields suggests that it will play a limited role in the future with most bakery products. Fruits and vegetables have been frozen commercially in increasing amounts for 20 years or more, yet, according to figures now available on the 1953 pack of frozen and canned fruits and vegetables, vegetables frozen were only about 20% of the canned pack, and fruits frozen were about 40% of the canned-fruit pack. The higher percentage of frozen fruits is accounted for by the large amount of citrus juices frozen — more than half of the frozen-fruit pack. Excluding citrus juices, frozen fruits were only about 17% of the canned. Thus, even in an industry where preservation is essential, the older method is still ahead. In the baking industry long storage of products is not a necessity. A wide variety of products is available daily over the entire country. Again, most of the ingredients used, such as flour, sugar, and fats, can be stored and transported cheaply and are widely available throughout the year. Other ingredients, such as eggs and seasonal fruits, can be stored frozen at lower cost than in bakery products, either baked or unbaked.

We believe that frozen bakery products cannot compete with the fresh on price. Acceptability will, therefore, have to be based on other factors. From our experience we conclude that freezing does not improve bakery products; at best it merely preserves, the degree of preservation depending upon the manner in which the products are made and handled. Thus, claims for better quality are not defensible.

On the other side of the picture, there is indication that consumers will accept frozen bakery products and, even if the amount sold is only a small percentage of the baked goods produced, it may amount to substantial tonnage. Thus, in dealing with this subject one is persuaded to desert the restricting confines of economic facts and figures and to delve into possibilities, using scientific data as the only restrictions.

For example, bakeries might borrow the methods of canning plants or vegetable-freezing plants. One bakery might manufacture merchandise, freeze it, and distribute it frozen throughout the United States. A definite schedule could be set up, for an 8-hour day or a 16-hour day. Night work could be eliminated, if desired. The only deterrent to this sort of thing is the cost. It has been pointed out that on long hauls, the cost of deep-freezing and transporting a product destined for distant points is less than daily transportation of small unfrozen shipments, because shipment can be made in full carloads or truckloads. This, of course, is not true for a bakery operating normally, with short hauls. At this time a bakery cannot freeze and ship 1200 miles and compete successfully with another one that has neither freezing nor shipping charges.

Another possibility in freezing bread would be freezing individual unwrapped slices of bread very rapidly and reassembling them into loaves of different sizes, leaving out the heels. The reassembled slices could be wrapped, placed in shipping cartons, and stored in the freezer. Individual, unwrapped slices direct from the slicer could be carried on a continuous stainless-steel-mesh belt passing through an opening between upper and lower freezing plates, just high enough to permit the horizontal slice to pass through. Temperature of the plates could be approximately —45.6°C. (—50°F.), so that the slices would freeze in a few minutes. With such rapid freezing the slices would stale very little, and the insulating effect of the packaging material and the product's own bulk would be eliminated. Such a rapid-freezing method would improve the frozen bread and also give flexibility in the size of loaf to be packaged.

Opportunities for Further Research

Although freezing is one of the most promising ways at the present time to retard bread staling, it would seem that other possibilities exist and that in some ways they might prove to be even more feasible.

Since bread can be kept fresh at 140°F. or can be refreshened by heating to 140°F., these factors may possibly be utilized to develop methods for preserving freshness. Thus, bread suitably wrapped can be refreshened in less than a minute by heating it in a radio-frequency field or for a longer time in an oven. For short keeping times up to 1 week, a cellophane wrapper of a special type would be suitable. For longer times it might be necessary to sterilize and can the bread, to be heated in an oven for refreshening. Consideration should be given to the costs of these methods because, for short holding periods, they might well prove less expensive than freezing.

Although realization of these thoughts may seem improbable at this time, with future technological advances some of them may even become commonplace.

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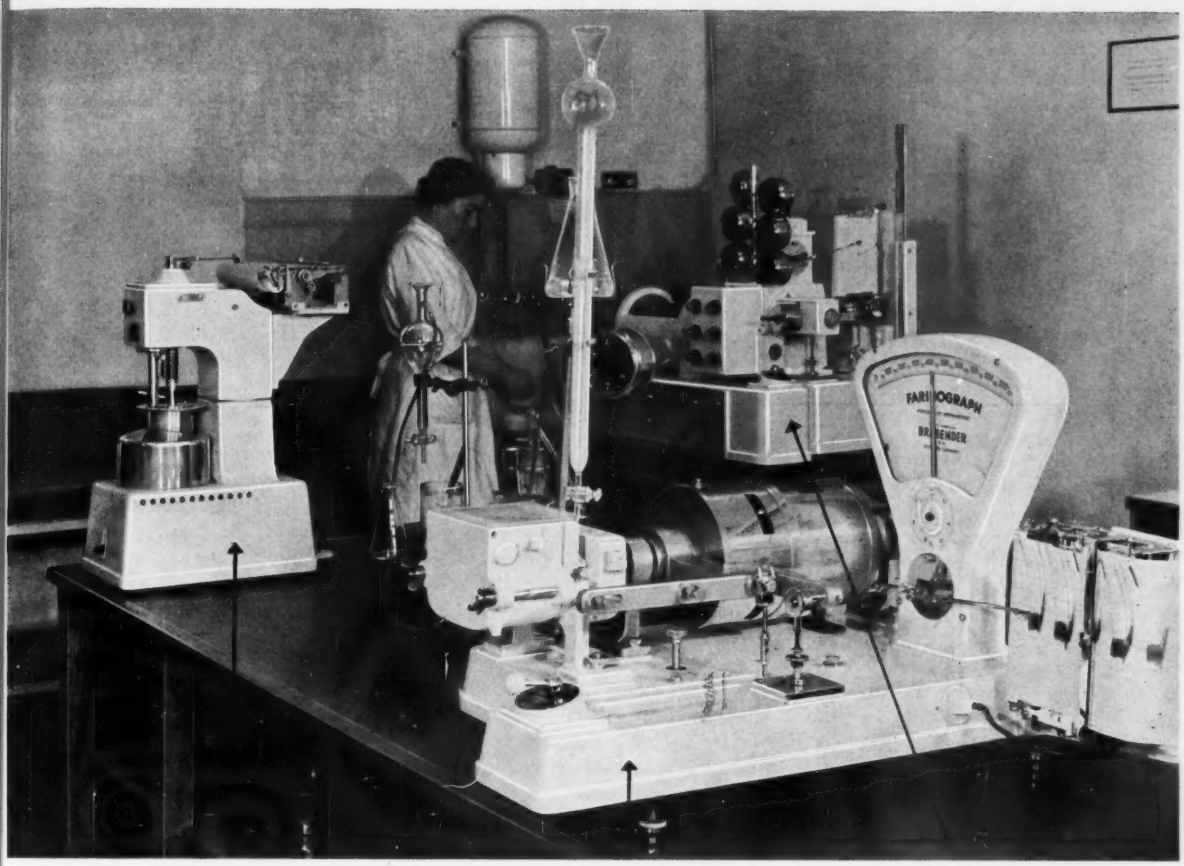

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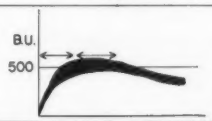
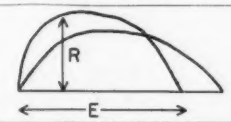
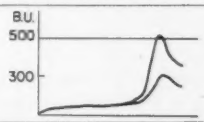
A Typical Brabender Flour and Dough Testing Laboratory Using *the* *Three-Phase Conception of* Baking Performance

	I PHASE Dough Mixing	II PHASE Fermentation & Machining	III PHASE Oven Period
Measuring Instr. Used	***Farinograph***	***Extensigraf***	***Amylograph***
Type of Indication			
Information Obtained	Absorption, mixing time, mixing tolerance (general strength)	$\frac{R}{E} = \frac{\text{Resistance}}{\text{Extensibility}} =$ Degree of Maturing (Indicating fermentation and machining behavior)	Crumb formation characteristics (Controlling crumb softness and rate of staling)
Correction Possibilities in a flour mill:	Changes in wheat blend	Adjustment in "bleach" (chemical maturing agents)	Mill stream switching and/or malt additions (diastasing)
in a bakery:	Absorption and mixing changes	Adjustment of yeast food	Malt additions

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A NEW AGENT FOR FLOUR BLEACHING AND MATURING

Chlorine Dioxide Hydrate

by R. C. Sherwood*

THE OLDEST MATURING and bleaching agent is the atmosphere, the air we breathe. Long before flour was exposed deliberately to chemical agents, it had been learned by millers that flour improved with age. The main reason for baking improvement is undoubtedly the slow oxidation of the reducing substances in flour and the consequent reduction in protease activity. Color becomes whiter because carotenoid pigments are partially oxidized. But 30 weeks' natural aging doesn't remove as much color as less than 30 seconds' exposure to gaseous bleachers.

Fifty years ago, long storage of flour did not seem onerous. Furthermore, mechanical mixing at high speed was unheard of, and timing of baking schedules could not conceivably have been of the importance it is today. Now, bakers are not content with the limited improvement in baking properties and the relatively slight bleaching caused by air entrapped in flour as it is milled.

Flour bleaching with chemical agents is quite old. As early as 1879, a British patent was granted to Beans for bleaching with chlorine. Both French and British patents were granted to Frichot in 1903 for the production of ozone by a flaming arc for the purpose of bleaching flour. Bailey (3) states that the active agent was probably nitrogen peroxide instead of ozone.

Chemical agents were first applied to flour in North America early in the present century. Snyder (8) in 1904 reported bleaching experiments. Records show that the oxides of nitrogen were the first agents used commercially. In the Andrews process, which was started in England (patented there in 1901) and then brought here, the gases were generated by adding nitric acid to ferrous sulfate. Nitric oxide (NO) was produced and this was converted into nitrogen tetroxide (NO_2) by oxygen of the air.

When the flaming electric arc was introduced by Alsop and patented by him in 1904, this superseded the Andrews process for producing the gas. However, the reaction of nitric acid on metals was used commercially to produce nitrogen peroxide. In a short time it became common milling practice to bleach with the oxides of nitrogen. The gases obtained by passing air over a flaming arc are not pure, but the mixture consists principally of nitrogen tetroxide, highly diluted with air. The concentration is variable, of the order of 300 to 500 p.p.m. of air (0.03–0.05%).

While the original objective in this treatment seemed to be color removal, it was soon found that baking properties were improved also, and that the storage period could be shortened.

Other agents for bleaching and maturing have been introduced since then. The search for new agents, principally for their maturing effects, has intrigued many researchers. Well over a hundred U. S. patents and many foreign ones have been issued, and a much larger number of research papers have been published. The list of agents investigated is long. Following are three groups (admittedly incomplete), some of which are of academic interest only; these are arranged according to their action in flour and dough: A, those which bleach with incidental or no maturing action; B, those which mature with little or no bleaching action. All of the B group will cause improvement in grain, texture, and color of bread crumb, but not in color of dry flour. The C group, obviously, contains those which bleach and mature.

Group A:
- Benzoyl peroxide
- Fatty acid peroxides
- Other organic peroxides
- Hydrogen peroxide
- Enzymic agents

Group B:
- Bromates
- Iodates
- Persulfates
- Phosphates
- Calcium peroxide
- Calcium salts
- Ascorbic acid
- Succinic acid
- Malic acid

Group C:
- Oxygen
- Ozone
- Oxides of nitrogen
- Chlorine
- Hypochlorites
- Chloramines
- Nitrogen trichloride
- Nitrosyl chloride
- Chlorine dioxide
- Carbon tetrachloride

Wheat flours vary widely in their baking characteristics and in their response to oxidation. The variations are due primarily to the quantity and physical properties of the proteins. It is the sulfur-containing amino acids, cysteine, cystine, and methionine, in gluten which are involved in the oxidation and reduction reactions when flour is exposed to maturing agents. These agents act upon a sulfhydryl-phosphoric acid linkage which can be released by proteolytic enzymes.

The specificity of the several agents, as well as the varying sensitivity of flours, is an important considera-

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tion. Selection of the right oxidizing agents, the right concentrations, and, in fact, the preferred order of application when multiple agents are used, was recommended by Ferrari, Hutchinson, and Derby (6) in 1947.

The United States standards for flour (2) include the following optional bleaching and maturing agents: oxides of nitrogen, chlorine, nitrosyl chloride, chlorine dioxide, benzoyl peroxide, and potassium bromate. When potassium bromate is added, the flour must be labeled "bromated." The use of any or all of the others requires that the word "bleached" be included in the flour labels. Canadian flour standards (1) permit the use of the same agents, plus ammonium persulfate. Doty and Sherwood (4) described the maturing properties of ammonium persulfate in 1950.

The newest agent to be added to the optional agents in the standards for flour is chlorine dioxide. It replaced nitrogen trichloride.

Chlorine dioxide was made in the laboratory as early as 1801. Cruickshank in 1801 and Chenevix in 1802 reported a compound of oxygen and chlorine in the gas obtained by the reaction of sulfuric acid and potassium chlorate. In 1815 Davy announced the discovery of chlorine dioxide. Earlier reports did not identify the gas as the dioxide.

Numerous reports were published in the literature in the 1800's about the properties of chlorine dioxide; thus, it is apparent that its powerful oxidizing properties have been known a very long time. The fact that the compound is not sufficiently stable to be compressed and shipped in cylinders, as chlorine is, probably delayed its industrial use.

The use of chlorine dioxide for flour bleaching was reported as early as 1928 when Staudt obtained a British patent covering treatment of flour with this oxidizing agent. Later, in 1933, a U. S. patent was granted to Becher[1] for chlorine dioxide bleaching in combination with certain other oxidizing treatments. Both of these basic patents have expired.

Flour bleaching with chlorine dioxide was described in 1941 by Ferrari, Hutchinson, Croze, and Mecham (5). They also reported that the maturing action was similar to that of nitrogen trichloride. The dioxide improved dough-handling properties and increased loaf volume, when 0.25 g. chlorine dioxide per cwt. was the treatment. However, when 0.75 g. per cwt. was added to the flour to reduce the carotenoid pigments from 2.92 to 0.75 p.p.m., the flour slick score was "dull" and loaf volume was reduced. This showed that chlorine dioxide should not be relied on for the full bleaching effect as the maturing action is likely to be excessive.

Experiences of many cereal chemists have shown that a judicious combination of chlorine dioxide and benzoyl peroxide will achieve both bleaching and maturing objectives.

In the early experiments Ferrari *et al.* used the electrolytic process of Logan[2] for generating the gas, but later they bleached and matured flour with chlorine dioxide produced by reacting chlorine with a solution of sodium chlorite, the process developed by Logan and Petroe[3] (later modified by Woodward), and by passing chlorine gas through dry sodium chlorite, the process patented by Hutchinson and Mecham.[4] All three of these processes were described in 1944 by Woodward, Petroe, and Vincent (9). Each of them employs sodium chlorite and requires a generator to liberate chlorine dioxide gas at the site of its use.

As described by Woodward *et al.* (9), the way to produce sodium chlorite is first to make chlorine dioxide gas from sodium chlorate and pass the gas into sodium and calcium hydroxides. The sodium chlorite thus formed can be separated from the by-products and dried.

These authors (and others) have described the properties of chlorine dioxide at ordinary temperature and pressure: a yellowish to reddish irritating gas with an unpleasant smell; vapor density about 2.4; cannot safely be compressed in tanks. In high concentration, it can present a hazard and in these properties it is akin to nitrogen trichloride. Like the latter, safety in flour bleaching depends largely upon its high dilution with air. Woodward *et al.* stated that in gas-air mixtures, a partial pressure of 30 mm. Mercury for the chlorine dioxide is safe for industrial use under ordinary conditions. Since the high dilution with air in flour bleaching reduces the partial pressure to about 2 mm. Mercury, an ample margin of safety is provided.

Woodward stated that the oxidizing power of chlorine dioxide, expressed in terms of "available chlorine," is 2½ times that of chlorine itself. He illustrated this on a molecular basis as follows:

$$ClO_2 + 2\tfrac{1}{2}\,H_2 \text{———} HCl + 2\,H_2O$$
$$Cl_2 + H_2 \text{———} 2HCl$$

It is interesting to note that this computation, although correct, bears no relation to the specificity of chlorine dioxide as a maturing agent for flour. Roughly, it takes 20 times as much chlorine to approximate the maturing effect of chlorine dioxide, and even then the maturing results are not identical. It takes about two or three times as much nitrogen tri-

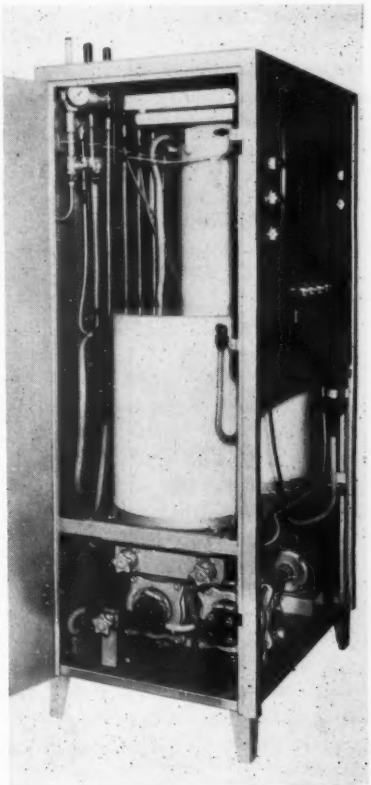

Fig. 1. Dispenser for utilizing blockettes of chlorine dioxide hydrate; left side view, with door ajar.

[1] Becher, W. Process for improving the color and the baking quality of flour, meal, and milling products. U. S. Patent No. 1,910,741 (1933).

[2] Logan, J. O. Production of chlorine dioxide. U. S. Patent No. 2,163,793 (1939).

[3] Logan, J. O., and Petroe, G. A. Chlorine dioxide. U. S. Patent 2,131,447 (1938).

[4] Hutchinson, W. S., and Mecham, D. K. Manufacture of chlorine dioxide. U. S. Patent No. 2,309,457 (1943).

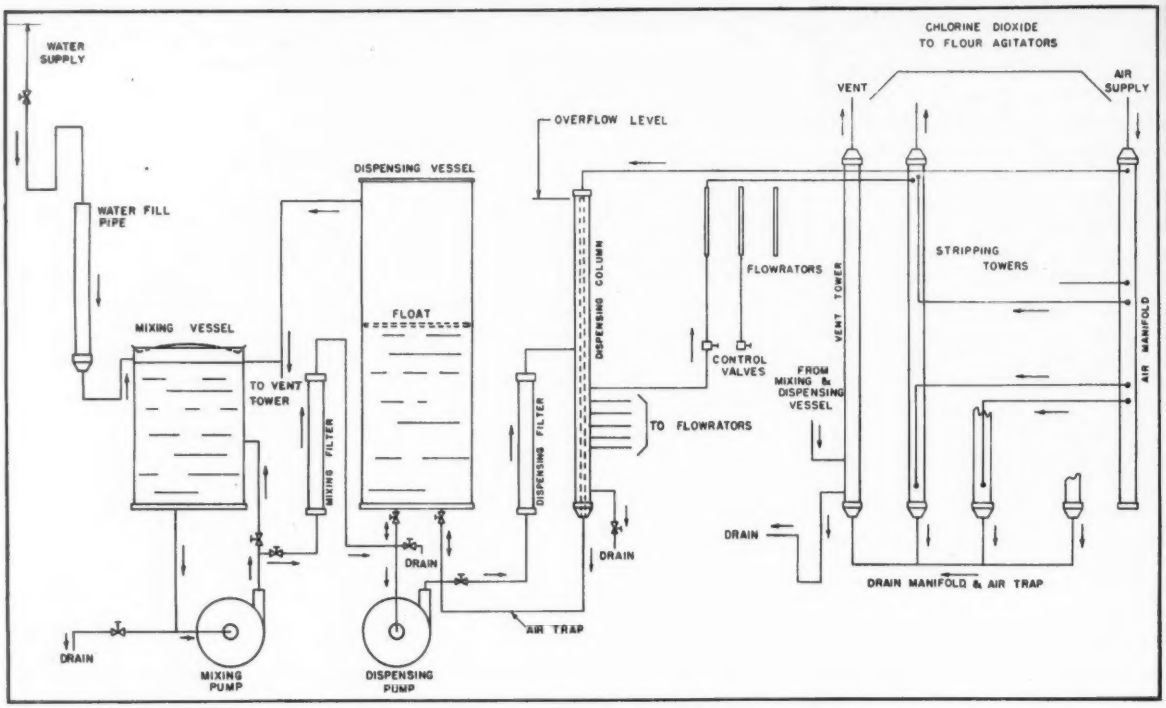

Fig. 2. Schematic flow diagram showing how dispenser operates.

chloride as chlorine dioxide to mature flour.

When chlorine dioxide replaced nitrogen trichloride in the Federal Standards of Identity for flour, chlorine dioxide-generating equipment was made available to the milling industry; the generators and their mode of operation were described in detail by Parker (7) in 1949. Basically, the system is that described previously by Woodward *et al.* (9).

A newer method for supplying chlorine dioxide for flour bleaching and maturing is with chlorine dioxide hydrate. The process for manufacturing the hydrate has been described by Williamson and Hampel.[5]

Although chlorine dioxide cannot be packed and transported as a gas or as a liquid, it has been found in rather extensive research that it is commercially feasible to produce chlorine dioxide hydrate ($ClO_2 \cdot 10H_2O$), store it, and transport it at low temperature. When chlorine dioxide hydrate is put into water, a solution of chlorine dioxide results. This is a common chemical phenomenon. There are many hydrated compounds which crystallize with definite ratios of water of crystallization, and when placed in water they make aqueous solutions identical in physical and chemical properties with the solutions of the anhydrous compounds. Classic examples are sodium carbonate ($Na_2CO_3 \cdot 10H_2O$) and cupric sulfate ($CuSO_4 \cdot 5H_2O$).

The hydrates normally have physical properties different from those of their components. Such is the case with chlorine dioxide hydrate. The decahydrate is a crystalline orange-hued substance. It is prepared by absorbing chlorine dioxide gas in cold water. Crystals of hydrate are formed which can be removed by filtration, packed wet, and frozen into a solid block. The hydrate does not decompose readily when stored at low temperature. It is not explosive; in fact, during investigation of its prop-

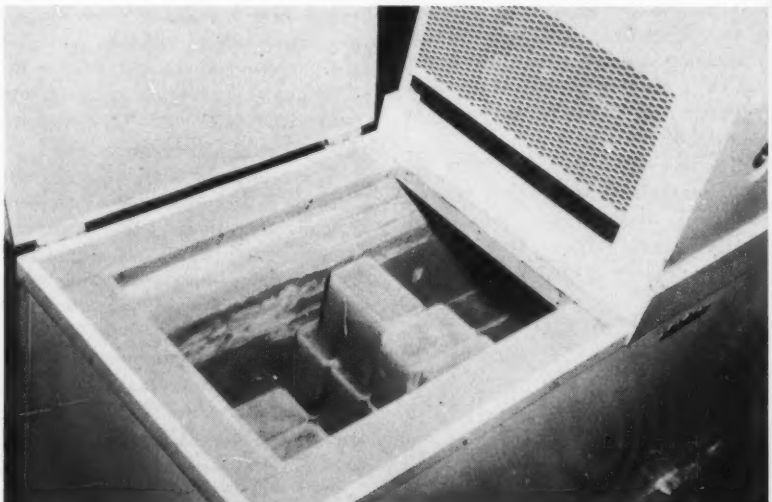

Fig. 3. Freezing cabinet for storing blockettes of chlorine dioxide hydrate, with cover lifted to show blockettes.

[5] Williamson, H. V., and Hampel, C. A. Non-explosive chlorine dioxide hydrate composition and process for producing same. U. S. Patent No. 2,683,651 (1954).

erties, attempts to detonate small quantities were unsuccessful. It can be prepared and frozen in water ice in various concentrations; the range of 10–20% calculated as chlorine dioxide is practical commercially. The frozen hydrate can be stored, if desired, for months at approximately 0°F. without appreciable deterioration or loss of chlorine dioxide by vaporization.

Chlorine dioxide solutions can be easily made, simply by placing a block of hydrate-ice in water, then agitating gently. For flour treatment, solutions of 0.5% to 2.0% are convenient to use. Such solutions can be metered to stripping towers where countercurrent streams of air pick up the chlorine dioxide, dilute it to low partial pressure of chlorine dioxide, and transport it through hose to flour agitators. The commercial equipment installed in flour mills for this operation is called a dispenser. It is not a generator. Frozen hydrate is the only ingredient required besides tap water and compressed air.

The concentration of the chlorine dioxide solution is controlled at a predetermined level by standardizing the weight of frozen hydrate blocks and the volume of water in the mixing vat. The flow meters are calibrated in grams of chlorine dioxide per hour. Valves control the flow of chlorine dioxide solutions and permit the operator to adjust the gas treatment of flour at any level.

Figure 1 illustrates a commercial chlorine dioxide dispenser. Figure 2 is a flow diagram for this dispenser. Since the frozen hydrate blocks must be stored at low temperature, a deep-freeze cabinet (similar to that in Fig. 3) maintains the reserve supply of hydrate at the proper temperature pending use in the water vat in the dispenser.

The dispenser illustrated permits individual control of gas to each flour agitator. Separate flow meters and stripping towers enable the operator to adjust gas treatment readily to the volume of flour handled in each agitator, independently.

Normally, operators need to make new solutions in the mixing vat only two to three times in a 24-hour period, depending of course upon the capacity of the mill. By throwing switches and adjusting valves, the operator can mix the solution and then transfer it by a pump to the operating tank, from which it is pumped to the stripping towers. When the mixing tank has been emptied, a fresh solution can be started at the convenience of the operator. Because of the cooling effect of the frozen block, about an hour is required to obtain complete solution.

In the construction of the dispenser, noncorrosive materials are used in critical places. The two tanks are made of polyethylene.

Baking results, laboratory and commercial, have demonstrated the value of flour treatment by the chlorine dioxide hydrate system. A few examples of laboratory bakes are shown in Tables I and II. Increased volume, better color score, improved

TABLE I

BAKING TESTS WITH SPRING WHEAT FLOUR UNTREATED AND TREATED WITH CHLORINE DIOXIDE FROM HYDRATE

TREATMENT WITH CHLORINE DIOXIDE	FLOUR COLOR[a]	LOAF VOLUME	CRUST CHARACTERISTICS	CRUMB COLOR[a]	GRAIN AND TEXTURE	GASOLINE COLOR
g/cwt	Spring wheat patent flour (ash 0.43%)					
Untreated	100 V C	2740	Sharp, green	99 V C	Tight, slightly harsh	79
0.1	100 C	2830	Smooth	100 C	Slightly tight, silky	87
0.2	100 B	2930	Bold, smooth	101 B	Excellent, silky	89
0.3	101 B	2950	Bold, smooth	101 B	Silky	90
	Spring wheat first clear flour (ash 0.73%)					
0.75	94 C-G	2970	Smooth	95 C-G	Silky	74
1.5	95 C-G	2915	Smooth	95 C-G	Sl. open, sl. stressed	78
3.0	96 C-G	2910	Slightly old	96 C-G	Open, stressed	86

[a] C = creamy; V C = very creamy; B = bright; C-G = creamy-gray.

TABLE II

BAKING TESTS WITH WINTER WHEAT FLOUR UNTREATED AND TREATED WITH CHLORINE DIOXIDE FROM HYDRATE

TREATMENT WITH CHLORINE DIOXIDE	ABSORPTION	FLOUR COLOR[a]	LOAF VOLUME	CRUST CHARACTERISTICS	CRUMB COLOR[a]	GRAIN AND TEXTURE
g/cwt	Winter wheat flour No. 1 (ash 0.44%, protein 11.06%)					
Untreated	63.5	99 B	2370	Smooth	99 B	Coarse, harsh
0.3	64.0	100 B	2570	Smooth	100 B	Close, even, sl. silky
0.4	64.0	100 sl D	2590	Smooth	100 sl C	Close, even, silky
	Winter wheat flour No. 2 (ash 0.46%, protein 12.2%)					
Untreated	64.0	99 B C	2660	Smooth	99 B C	Coarse, sl. tight
0.2	64.0	100 sl C	2775	Smooth	100 sl C	Close, even, silky
0.4	64.0	100 B	2860	Smooth	100 B	Close, even, silky
0.6	64.0	100 B	2850	Slightly rough	100 B	Open, stressed
	Winter wheat flour No. 2 (ash 0.46%) baked 2 weeks later					
Untreated	65.2	99 B C	2750	Smooth	99 B C	Slightly open, silky
0.2	65.2	100 B, sl C	2860	Smooth	101 B-W	Excellent
0.4	65.2	100 B	2910	Slightly rough	100 B	Close, even, silky
0.6	65.2	100 sl D	2820	Rough	99 sl D	Slightly stressed, silky
	Winter wheat patent flour No. 3 (ash 0.42%, protein 11.2%)					
0.15	63.5	100 B	2860	Smooth	100 B; sl C	Slightly open, silky
0.20	63.5	100 B	2790	Slightly rough	100 B	Silky; excellent
0.25	63.5	100 sl D	2710	Rough	100 B	Stressed
	Winter wheat clear flour No. 4 (ash 0.60%, protein 13.6%)					
1.0	65.0	93 C-G	2830	Smooth	93 C-G	Close, even, sl. coarse
1.25	65.0	94 C-G	2930	Smooth	95 C-G	Close, even, silky
1.5	65.0	94 C-G	2870	Slightly rough	94 C-G	Slightly open, silky

[a] B = bright; C = creamy; D = dull; C-G = creamy-gray; B-W = bright white.

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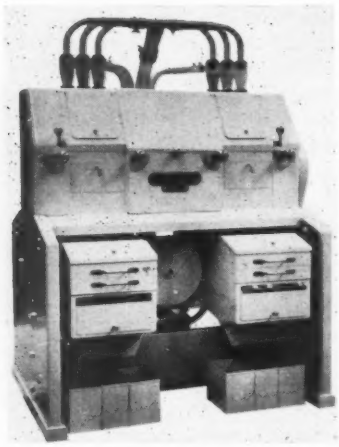

Front side of the MLU 202 Buhler Automatic Laboratory Mill; equipped with pneumatic product conveying which eliminates material collecting in the ducts and resultant infestation.

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The MLU 202 Laboratory Mill was designed primarily to produce flour from any specific sample of wheat so that advance information may be obtained as to what can be expected in yield, ash content, color and baking qualities of the sampled wheat, without running it through a commercial unit. The Buhler MLU 202 has the same advantages as a pneumatic mill in comparison with an elevator mill.

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grain and texture of crumb are apparent.

Summary

Chlorine dioxide hydrate is a very satisfactory agent for providing chlorine dioxide to mature flour. This has been amply demonstrated in commercial flour mills. The system described here enables chemists and millers to adjust chlorine dioxide treatment accurately, to maintain the desired treatment uniformly, and to check the rate of chlorine dioxide application easily by glancing at a flow meter. A refrigerator for storing frozen hydrate, a dispenser for utilizing it, and hose for delivering the gas-air mixture to flour agitators comprise the essential equipment. The dispenser has individual precision controls for each flour agitator.

Acknowledgment

The author hereby acknowledges gratefully the work of associates who have contributed to the research on chlorine dioxide hydrate, the development of the dispenser, and the laboratory baking tests, particularly the following persons (listed alphabetically): J. M. Doty, C. A. Hampel, J. C. Hesson, W. F. Keller, R. S. Whiteside, and H. V. Williamson.

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NEW HORIZONS IN FOOD PRESERVATION AS

Atoms Strike The Cereal Industry

by Reuben Pomerantz*

THE PRODUCTION AND handling of subsistence is one of our nation's largest industries, amounting in annual sales to about 60 billion dollars, with 165 million Americans spending daily more than 35 million dollars in some 500.000 retail food stores. No industry faces a greater challenge than that of bringing the world's food supplies economically and efficiently to your dining table. But economy and efficiency must wage a constant and heretofore losing battle against waste.

Although great strides have been made in the last few decades toward improving methods of food preservation, several factors have dictated a continuous and seemingly endless search to add a "third dimension" to our two principal processes — heating and refrigeration. Among these factors are food losses caused by spoilage and insect infestation, the quest for improved quality, and our population increase of 1½% per annum. Current methods of preservation enable the food processor to fulfill his daily commitments, but fall far short of our needs. Nationwide annual losses in fruits, vegetables, and livestock equal the production of 32 million acres, and losses caused by rodents and insects in stored food total 6 million dollars. By 1975 we shall have a production deficit of 90 million acres unless we can reduce food spoilage substantially.

A Third Dimension for Food Processing

Atomic energy may well provide this sought-for "third dimension": ionizing radiation adapted to the food industry. For the consumer, the arrival of the atom on the farm may well herald cheaper and better foods, of improved quality and stability through the food processor's contributions.

Contrary to many optimistic predictions which have appeared in the press, the age of radiation processing of food is not yet here. However, possibilities for the future are certainly encouraging and appear to warrant the intensive research program now being sponsored by the Department of the Army, under the over-all supervision of the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois.

There is nothing mysterious concerning the use of atomic energy to preserve foods, nor is the basic principle a new one. Soon after X-rays had been discovered by Roentgen in 1895 it was shown that they could penetrate matter with ease and could bring about death of living cells. The properties of X-rays and other forms of ionizing radiation have been widely exploited over the years, but their application was not focused on the food industry until the close of World War II, when radioactive by-products of the Atomic Energy Commission's program became available and high-energy particle accelerators were developed.

Nature of the Radiation Process

The revolutionary process of preservation by radiation employs nuclear energy instead of heat to destroy microorganisms which promote food decomposition and spoilage. Since in this process there is only a minute rise in temperature in the treated product during the short exposure time of seconds or minutes, this method is often called "cold preservation."

Although the ultimate destructive effect is still not clearly defined, it is currently believed that nuclear rays strike microorganisms much in the same manner as a fast-moving projectile strikes its target. These nuclear "bullets" either kill bacteria outright or so disrupt the vital functions of proteinaceous cells that they can no longer reproduce (Fig. 1). In addition to this direct action, the so-called "indirect" effect of ionizing radiation may eventually destroy microorganisms by ionizing the surrounding medium.

Source of Radiation Energy

Of the numerous forms of electromagnetic radiations and particulate beams available to the nuclear physicist, cathode rays and X-rays or gamma radiations are the only types of paramount importance to the food industry.

Cathode rays are electron beams produced by man-made generators, the simplest of which consists essentially of an evacuated tube with a cathode (negative terminal) at one end and an anode (positive terminal) on the other. Millions of volts are needed to energize electrons for irradiation of foods, and thus the common terminology is Mev (million electron volts). Several types of electron accelerators appear to be feasible for radiation processing, the principal ones being the Van de Graaff generator, the resonant transformer (Fig. 2), the capacitron, and the traveling wave linear accelerator (Fig. 3). Commercial production

*Captain, Quartermaster Food & Container Institute for the Armed Forces, Chicago, Illinois.

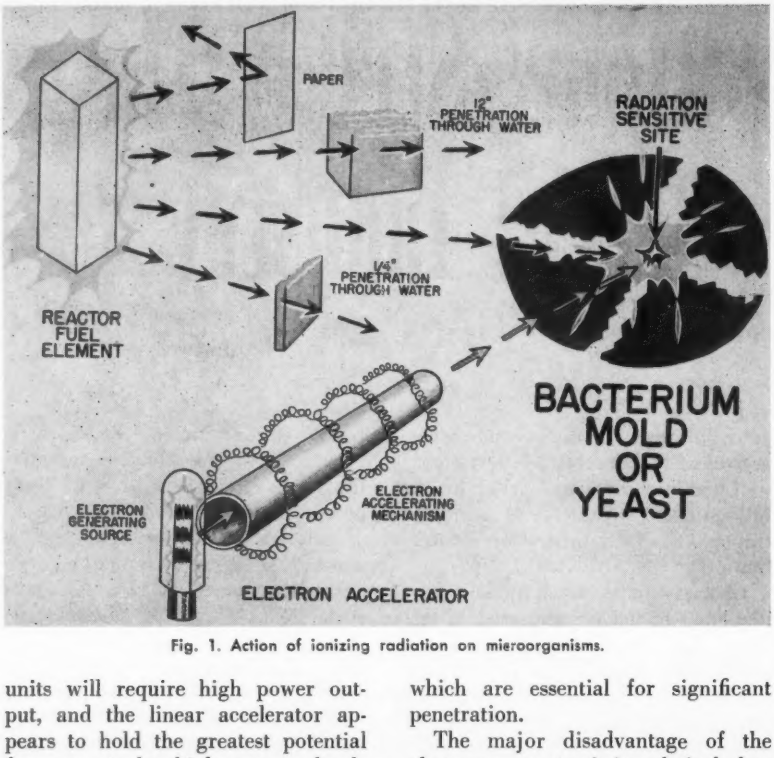


Fig. 1. Action of ionizing radiation on microorganisms.

units will require high power output, and the linear accelerator appears to hold the greatest potential for use at the high energy levels which are essential for significant penetration.

The major disadvantage of the electron generator is its relatively low penetration. Depth of penetration is a function of electron energy and target density. For unit density material a 1-Mev machine will penetrate, with uniform dose on both external surfaces, approximately 1/8 inch. A double pass or cross firing will extend this distance about 2½ times or a total of about 0.3 inch per Mev.

X-Ray Machines. X-rays can be produced by bombarding suitable heavy metal targets with electrons. Although penetration is greater by this method, there is tremendous loss of energy in the form of heat at the target surface. Because of this energy loss in converting the electron beam to X-rays, and reduced utilization per given volume because of its high penetration, the beam power of an X-ray machine must be about five times as great as for the same machine using electrons directly.

Gamma Rays. Gamma rays have the same physical characteristics as X-rays; they are not produced by machines but are emitted from the atomic nucleus during radioactive decay. Their absorption in matter is exponential and thus not finite but,

Fig. 2. 1-Mev. General Electric resonant transformer.

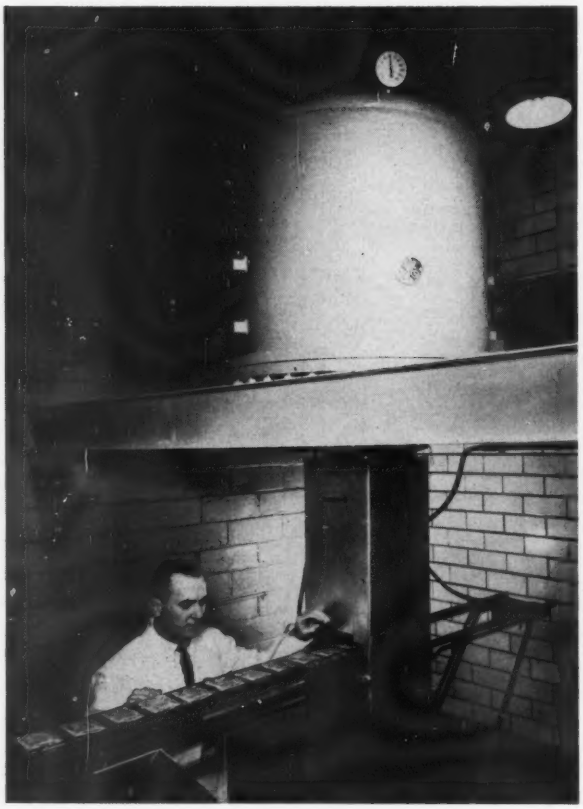
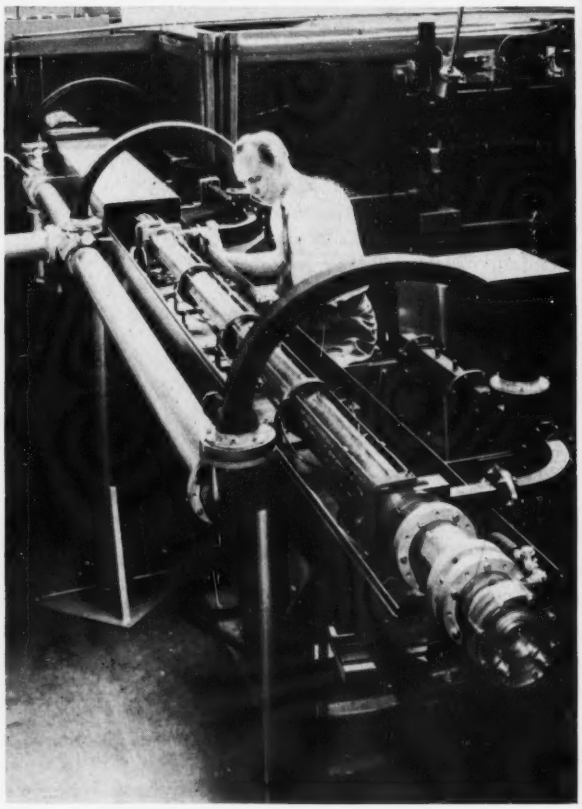


Fig. 3. 50-Mev. high-voltage Engineering Corp. Linear Accelerator



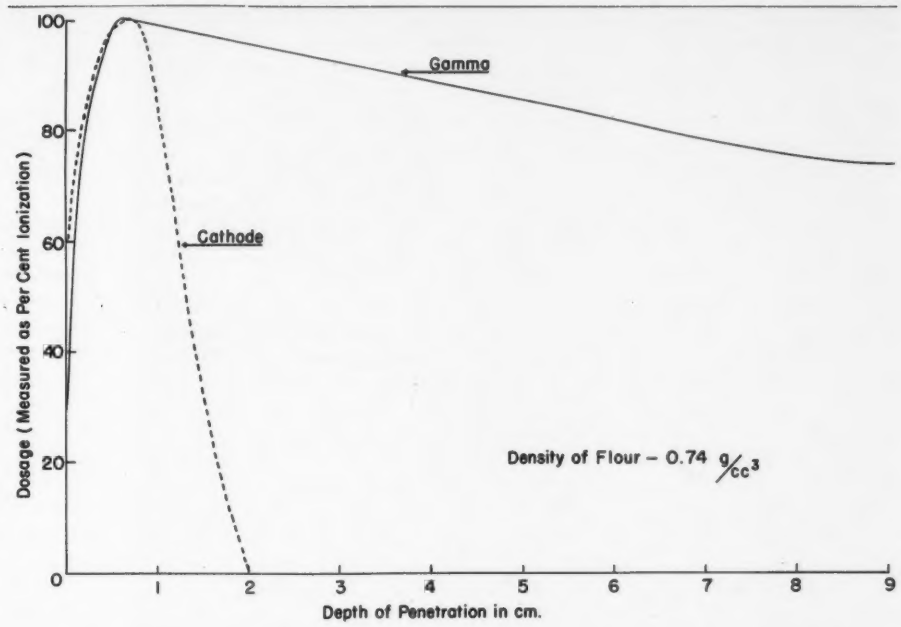


Fig. 4. Dosage distribution vs. penetration in flour by 3-Mev. gamma and cathode rays.

as in the case of electrons, is dependent upon the energy of the incident rays and the density of the material being treated. The half-thickness of H_2O (the amount of water required to reduce the initial intensity of a 1-Mev photon of X energy to one-half its initial intensity) is about 5 inches (Fig. 4).

Commercial radiation processing will require very large sources of gamma radiation, which nuclear reactors may in the future provide. Several forms of gamma radiation can currently be considered as feasible for future food processing:

1. Spent fuel elements — used fuel rods of fissionable material withdrawn from a heterogeneous (solid fuel) reactor to cool prior to reprocessing.
2. Gross fission products — atomic wastes recovered from reactor operation.
3. Separated fission products — specifically isolated constituents of reactor waste products.
4. Fission product gases, produced from nuclear fission in a homogeneous (liquid fuel) reactor.
5. Radioactive isotopes produced in reactor by neutron bombardment.

Each of the above potential sources has its advantages and limitations. Selection of the most appropriate one for any given processing line will no doubt depend on the dimensions and physical characteristics of the food being processed and the availability and economics of the source supply.

Reactor Fuel Elements. These elements, which are most widely used in our program today, have the major advantage of being relatively inexpensive. This assumption is based on the premise that the future atomic power program will provide an abundance of elements and that shipping costs can be satisfactorily resolved. The major limitation is nonuniformity of energy spectra and major drop-off in activity with elapsed time.

Gross Fission Products. These have the same limitations as spent fuel elements, and here again some of the low-energy gammas may cause a considerable overdose on the surface of the product. In addition, considerable time and expense are involved in chemical separation and in attaining the required concentration. Their principal advantage over fuel elements is that they do not tie up the considerable inventory of expensive fuel.

Separated Fission Products. These offer the advantage of selecting a specific element with a known half-life (the time required for its initial intensity to be reduced by half) and a uniform energy spectrum. Cs^{137} appears to promise well in this respect, since it has high energy and a half-life of 30 years. Its principal disadvantages are the difficult separation process and limited availability. However, this situation should improve as separation technology develops and as more chemical processing plants are constructed.

A homogeneous reactor of the water boiler type could be designed, using fissionable material in solution, and the resulting gaseous products could be piped off and pumped through coils into the irradiation chamber. Since the principal active *fission product gases* (namely xenon, krypton, and iodine) have half-lives of only 7 to 17 seconds, these gases must be removed rapidly. In addition, gamma rays produced from these gases will be accompanied by neutrons which are, of course, undesirable because of the possibility of their causing induced radioactivity, depending upon the specific item treated and the time of exposure. There is thus considerable engineering technology still to be developed in this field.

Induced radioactivity also crops up in the use of electron generators or high-energy gammas. Investigations are currently under way to determine what the maximum safety energy will be. This is of prime importance, since energy defines penetration. Current theoretical calculations indicate that energies up to a few Mev present no apparent problem. Electron energies of 10 to 15 Mev which can penetrate 3 to 5 inches also appear to be acceptable, but the safety of these figures must be confirmed by direct experimentation. Energies above 15 Mev may well pose problems with regard to induced activity. Fortunately, however, most food elements have high activation thresholds, and this induced activity should not constitute a serious biological hazard.

Isotopes. Turning now to isotopes produced in reactors by neutron bombardment, Co^{60} is currently in

wide use. It has a 5.27-year half-life and is of uniform energy. In addition, elements such as manganese and sodium, incorporated in a fluid to be passed through the core of the reactor or in the reactor coolant, have been suggested as sources of gamma radiation. Also, the fluid fuel of the reactor can be pumped from the core of a reactor to an external loop, providing a source of intense gamma energy. However, radioisotopes in megacurie quantities will be required for commercial units, and unless production reactors can be used, no such quantities will be available in the near future. The total amount of isotopes delivered in the past 8 years has been only 55,000 curies.

It is readily apparent, then, that there are many potential sources of gamma or electron radiation. Current work sponsored by the Department of the Army will aid in determining those forms which offer the best chance of success to the food processor.

The Problem of Food Acceptability

Undesirable Changes from High Radiation Dosages. Although development is still in its early stages, research clearly indicates that commercial sterility can be attained and that the process has potential for commercial adaptation. To attain sterility, doses of 1.5 to 4.0×10^6 rep[1] are required. Unfortunately, along with the drastic effect upon food spoilage microorganisms at these high dosages, subtle biochemical changes may alter color, odor, flavor, or texture. The chemical reactions responsible for alteration of flavor and odor are thought to be oxidative and reductive. Means have been devised to offset or diminish these undesirable effects through use of additives or free radical acceptors, or by changing the physical environment during irradiation. Obviously, until foods can be made fully acceptable, the advantages of "cold preservation" cannot be fully realized; therefore present efforts are being directed largely toward controlling these undesirable sensory changes. A number of items such as pork, pork sausage, bacon, sweet potatoes, Brussels sprouts, green beans, chicken, beef liver, and halibut fillets have been able to withstand these high levels of irradiation without deleterious effects.

Mild Pasteurization Plus Refrigeration. In contrast to sterilizing radiation dosages and the undesirable changes caused by them, relatively low radio-pasteurization treatment can be given to many foods without altering acceptability. Such a process, utilizing 2–10% of sterilizing doses (50,000 to 500,000 rep), can reduce microorganisms 90–99%, and post-irradiation refrigeration can prevent the residual microbial population from reproducing. This type of treatment may have a significant impact upon the wholesaling and retailing of fresh prepackaged meats, since refrigerated shelf life after irradiation can be extended as much as five-fold. It may also reduce losses in fresh fruits and vegetables. Preliminary investigations indicate that certain highly perishable commodities such as strawberries, coleslaw, and lemons can have their shipping time and shelf life extended manyfold by use of mild surface or pasteurization treatments.

In this category there seems to be a highly significant potential for the baking industry. Prepackaged baked and partially baked items such as "brown-and-serve" products, waffles, white bread, pound cake, and English muffins have been exposed to doses of 5×10^5 to 1×10^6 rep. Although acceptance ratings are often depressed at higher dosages, the items still score well into the acceptable range, and in many instances panel members cannot differentiate between irradiated and nonirradiated samples. Many such items have been held for months at room temperature, even the highly perishable waffle and English muffin, with only minor organoleptic changes. Changes in formulations may well provide the key for long-term unrefrigerated stability of certain irradiated prebaked or brown-and-serve-type bakery products (Figs. 5, 6, 7).

Potential Applications of Radiation

According to reports, at least 100 million pounds of bread are ruined by mold each year in bakeries and retail outlets. Mold damage to food products in general has been estimated as costing more than a million dollars annually. Whereas chemical retardants merely slow down the growth of mold, ionizing radiation completely destroys it; and since relatively low doses are required, this should be a lucrative field for radiation.

In addition to low-dosage radio-pasteurization, attention is being focused on a relatively high pasteurization dose of approximately 1 megarep. Though not sufficient to preserve food indefinitely, this dose may prove adequate to appreciably prolong preservation of many foods. Certain highly perishable items so treated have been stored for many days without refrigeration, or for several weeks with refrigeration. Under this process, certain cooked or smoked meats, blanched vegetables, and other items in which enzymes have been inactivated could be packaged in heat-sealed flexible bags and stored for extended periods under refrigeration. If the product is of low acidity or low moisture content so that *Clostridium botulinum* is not a factor, storage may be maintained at room temperature.

Successful Uses of Radiation

The last dose range worthy of special consideration is that in which there is substantial evidence to indicate success—limited radiation doses of several thousand to 100,000 rep.

Delaying of Sprouting. Relatively low doses of 8,000 to 15,000 rep have effectively inhibited sprouting of onions and potatoes. In addition, reduced weight losses and lower respiration rate have been reported in long-term storage studies. This field appears to hold great promise and is of particular interest to the potato chipper.

Destruction of Food-Borne Helminth. A dose of 25,000 rep has been sufficient to break the cycle trichinosis caused by consumption of fresh pork infested with trichinae. Recently, eight other similar diseases caused by meat, fish, and poultry in different parts of the world have been cited as possibly being susceptible to control by irradiation of the host meat.

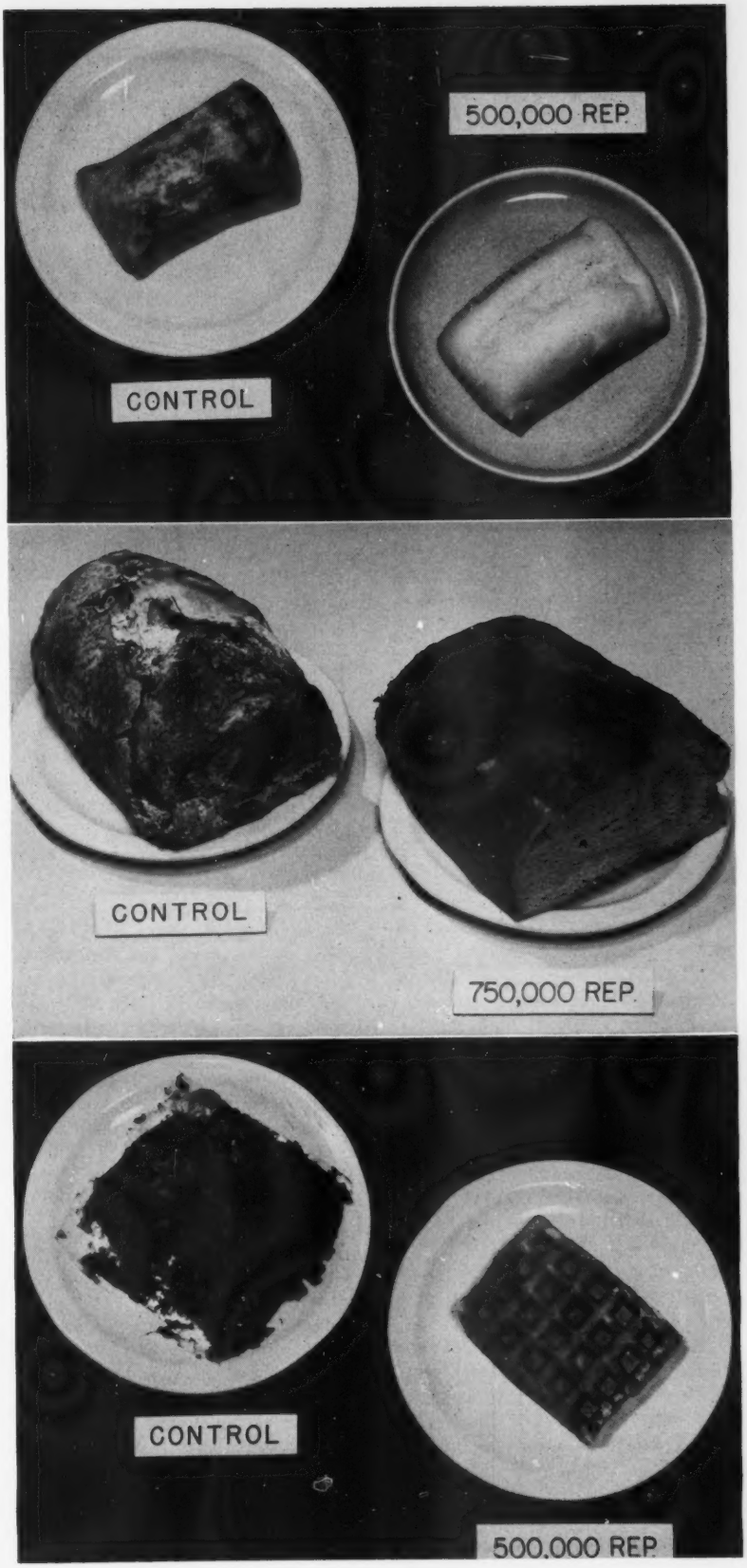
Deinfestation of Cereals, Grains, and Spices. Insect infestation of commercial cereal grains, cereal products, dried fruits, and military ration components made therefrom has for

[1] One rep (roentgen equivalent physical) is equivalent to the absorption of 93 ergs per gram of material of unit density.

Fig. 5. Rye bread: Irradiated Nov. 10, 1955; stored at room temperature for 2 months. Radiation source: Gamma (Facility Materials Testing Reactor). Photographed Jan. 10, 1956.

Fig. 6. Brown-'n-serve rolls: Irradiated October 5, 1955; stored at room temperature for 2 months. Radiation source: MTR (Gamma). Photographed December 10, 1955.

Fig. 7. Brown-'n-serve waffles: Irradiated October 5, 1955; stored at room temperature 2 months. Radiation source MTR (Gamma). Photographed December 10, 1955.



many years constituted a serious loss, costing more than $300,000,000 annually. High-frequency heating, pressure, sonic treatment, centrifugation, and chemicals have been widely used, but the search continues for a new approach to this old problem.

Ionizing radiations have effectively destroyed the common grain-infesting insects in all four stages of life—egg, larva, pupa, and adult—at dosages far less than those required for bacteria, yeasts, and molds. The rate of destruction is dependent upon the dosage used—the higher the dosage, the more rapid the kill. Exposure to ionizing radiation in low doses of approximately 12,000 rep destroys insects in all forms within a few weeks. Dosages of 25,000 to 50,000 rep have prevented insects from reproducing and from developing to later metamorphic stages; higher dosages, in the range of 400,000 rep, are required to destroy the insects instantaneously (Fig. 8). Experiments sponsored by the QM Food & Container Institute indicate that in cereal ration bars, fruit ration bars, brownie mixes, and gingerbread mixes, irradiation to levels at or below 100,000 rep will not adversely affect sensory qualities and will destroy all forms of insect life. Cereal bars so treated have been successfully stored for 1 year at 100°F. without significant changes.

Respiratory activity in stored grains due to common fungi has been a significant cause of deterioration, and it appears that fungal respiration can be completely eliminated by treatment with ionizing radiation.

Current Indications and Investigations

As for physical tests of flours subjected to irradiation, the following general pattern can be anticipated.

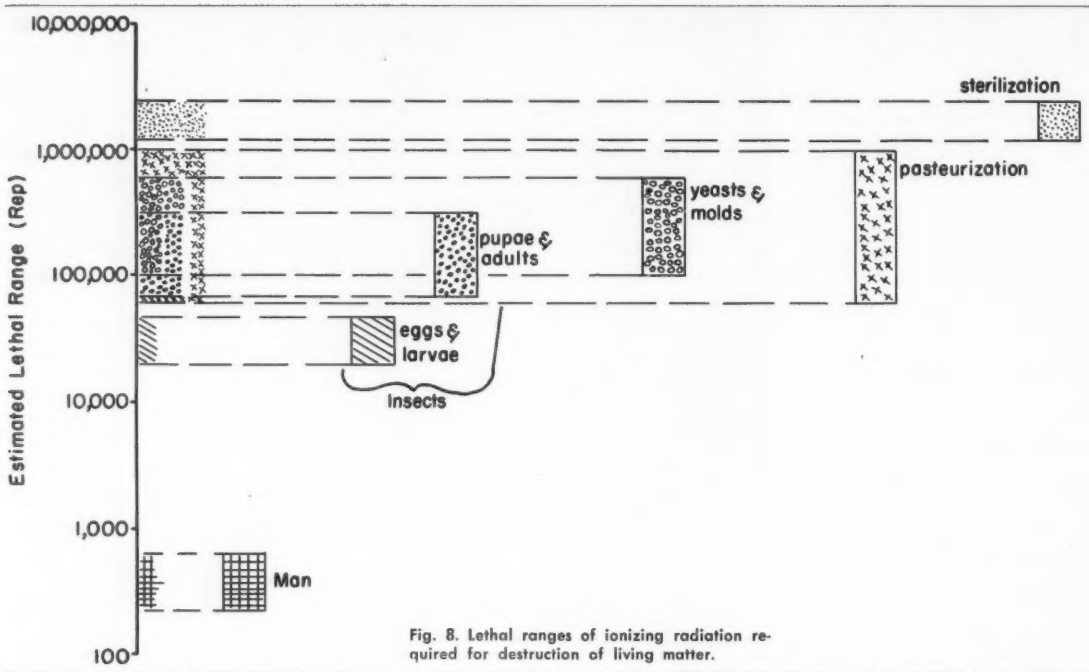


Fig. 8. Lethal ranges of ionizing radiation required for destruction of living matter.

Dough consistency, as measured by farinograph absorption, appears to decrease with irradiation; yet at very high dosages an increase is apparent. Dough development time decreases regularly with increased irradiation, indicating a protein degradation, and mixing tolerance also decreases at higher levels of irradiation, indicating further damage to protein and dough structure. Reduced elasticity and weakening of dough, as measured by the farinograph, can also be anticipated. With respect to amylograph determinations, high irradiation dosages appear to have a drastic effect upon viscosity. It should be emphasized, however, that these effects are pronounced only at higher dosages; *at lower levels of irradiation, the changes do not appear to affect acceptance of the finished product.* This has been borne out by numerous bake tests with irradiated whole-wheat flour and flour milled from irradiated Cornell wheat, at a level of 5×10^5 rep.

The Army has shown considerable interest in canned bread, and results to date indicate that this formulation, after baking, can be treated with irradiation dosages as high as 2×10^6 rep without significant organoleptic changes. Commercial bread, however, when irradiated in sliced form, appears to be changed considerably above 250,000 rep.

Paste products such as macaroni and spaghetti have been treated at levels sufficient to destroy various forms and types of insects (100,000 rep), and here again there is no apparent effect upon sensory qualities. This also holds true for various types of corn cereal.

Aware of national implications of the radiation of food, the Department of the Army has directed its effort toward drawing American food and allied industries into the program. In the hope of stimulating closer teamwork between industry and the military, the Army is sponsoring with industry many ventures in cooperative research and development. Those now in effect which I feel are of special interest to the cereal industry are: Quaker Oats Company, the effect of irradiation on cereal products such as oats and corn; Pillsbury Mills, its effects upon cake mixes and batters; and Doughnut Corporation of America, the application of radiation to such commodities as waffles and other prebaked goods. Negotiations are under way with other industrial groups, and the Army hopes that its list of cooperators will be ever-increasing. (Interested organizations should contact the QM Food & Container Institute, Chicago.

The effects of radiation on germination of seeds and mutation in plants are now receiving a great deal of attention at national laboratories and agricultural experiment stations. Work at Brookhaven has indicated that when corn seeds were irradiated, results were variable: some offspring grew taller and others shorter than the parent plant; some matured earlier, others later.

Investigators are currently experimenting with rust-resistant strains of oats and wheat. Blight-resistant oats and windstorm-resistant rice are also being studied. By controlling temperature and oxygen levels during mutation processes, researchers feel that they may be able to "tailor" seeds to fit any specific set of conditions.

What Problems Still Lie Ahead?

Principally, an understanding must be reached of the mechanism responsible for loss in acceptability. This apparent loss varies considerably from commodity to commodity and is proportional to the amount of irradiation employed. Fortunately for cereal and allied industries, dosages required will for the most part be relatively small, and this has proved to be a great asset. Once the mechanism of these changes is understood, control methods will have to be devised.

Much work is necessary to deter-

mine further exact dosages for commercial sterility, especially where food poisoning or intoxication is a factor.

The effect of irradiation on enzymes must be thoroughly investigated. It is now known that dosages of 5 to 10 times the amount required for sterilization are necessary for complete inactivation of enzymes. Yet in some cases sterility dosages appear to reduce enzymes to a dormant state without fully destroying them. Here again, the effect varies with the enzyme being treated.

As to packaging, work is needed on both rigid and plastic-type containers. The effect on enamel and sealing compounds in rigid containers must be determined, and physical characteristics of films must be investigated. The state of the art, as it is known today, seems to indicate that common packaging films are not significantly altered at the dosage levels of commercial sterility. At low levels for insect control there should be no undesirable effects, except for some slight discoloration of certain films.

Further investigations are needed to determine storage characteristics of irradiated foods at elevated, room, and refrigerated temperatures.

The entire field of radiation source availability requires further emphasis—to design and develop necessary equipment for both electron and gamma irradiation facilities. Considerable attention must also be devoted to dosage measurement and distribution.

Foods treated by ionizing radiations must be shown to be safe and wholesome when fed in large amounts over long periods of time. The Quartermaster Corps in close cooperation with the Office of the Surgeon General of the Army and the Food and Drug Administration, has developed a comprehensive and extensive program to provide this information. Animal feeding studies involving subacute and chronic ailments, and studies in human metabolism have been under way for some 18 months now and, to date, there has been no concrete evidence of toxic effects. Further, the program's first long-term feeding project is now under way: 70,000 pounds of potatoes were irradiated recently with 15,000 to 30,000 rep, for studies on long-term feeding and economic feasibility.

As for macro and micro nutrients, the degradation caused by irradiation does not appear to be greater than that associated with conventional processing techniques. Of the vitamins of specific interest to the cereal industry, thiamine appears to be most sensitive to irradiation, riboflavin more resistant, and niacin quite stable. Here again, vitamin losses will be sharply reduced at low levels of irradiation.

And finally, the process of using ionizing radiation must be shown to be economically feasible. Cost estimates today are hypothetical, since there are no proved costs of irradiation equipment of the type required by large-scale commercial production. Many persons have ventured estimates along this line, and the consensus would indicate the following ranges:

Sterilization (based on 2×10^6 rep)

	per lb.
Cathode ray generator	1– 5 c
Linear accelerators	0.3– 2.5c
Gamma irradiation	
Reactors	1.5– 7 c
Isotopes	3–10 c

Inhibition of Sprouting (based on 10,000 rep)

	per ton
Linear accelerators	$0.14–1.00
Fission products	$3.50–5.00
Reactor	$1.30

Deinfestation (based on 30,000 rep)

Linear accelerator	$0.10–0.74
Reactor	$1.00

It should be reiterated that the figures just indicated are based on many assumptions and forecasts. More accurate economic analysis will depend upon the actual pilot-plant runs which the Quartermaster Corps plans to undertake, utilizing new facilities for food preservation, to be constructed by the Department of the Army in conjunction with the Atomic Energy Commission. This pilot plant, capable of treating 1,000 tons a month with 2×10^6 rep, was announced by the President in his recent budget message to Congress and is expected to be ready by the close of 1958. Capacities for current sources are indicated in Fig. 9.

This report has presented a synopsis of the current status of the radiation program and, it is hoped, some insight into future problems. There are more corners to turn and more bridges to cross before a commercial process is realized. However, irradiation of cereals and grains may well be one of the early "break-throughs" in the program. Already it appears that fungal respiration, a significant cause of deterioration in stored grain, can be completely eliminated by treatment with ionizing radiation. With close teamwork of an extensive military-academic-industrial network, radiation may be added as a third dimension to the food processing industry.

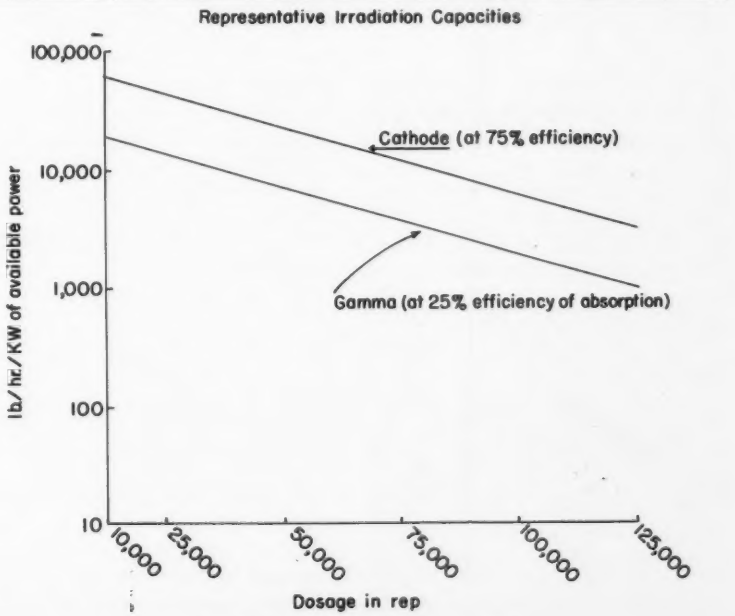


Fig. 9. Representative irradiation capacities.

Nestling at the foot of fabulous 42nd Street are the United Nations Buildings wherein the countries of the world seek peace in a very turbulent century. The 39-story Secretariat office building stands impressively over the low-domed General Assembly Building. In the background can be seen the world's two tallest buildings — the Empire State and the Chrysler Buildings. Photo, courtesy New York Convention and Visitors' Bureau.

A.A.C.C. Holds 41st Annual Meeting in New York

CONVERGING UPON THE world's largest city for its 41st annual meeting, the American Association of Cereal Chemists most appropriately is planning the largest technical program ever presented at one of its meetings. As indicated in the preliminary announcement which has already been distributed to the membership, the final technical program should number between seventy and eighty papers.

Program Chairman Gaston Dalby, of the Ward Baking Company, New York, is enthusiastic in reporting the splendid response and cooperation he has received from the many well-known scientists and individuals participating in this meeting. The numerous papers and discussions will emphasize what is being done to study and advance the future role of "cereal chemistry in a changing world." *Improvement* is the keynote, and improvement is generally reflected throughout the program which has been divided into six major classifications:

- Cereal Chemistry in a Changing World
- The Use of Cereals for Human Food
- Wheat Varieties and milling Technology
- Chemistry and Technology of Bread and Cake Doughs
- Chemistry and Technology of Baking
- Chemistry and Technology of Feeds

The Association is fortunate in having secured distinguished guest speakers for the opening session. Following the presidential address by Dr. William H. Cathcart of the Great Atlantic and Pacific Tea Company, New York, will be those of Dr. Charles Glen King, Executive Director of the Nutrition Foundation, New York; Dr. Raymond W. Miller of Washington, D.C., and the Harvard University Graduate School of Business Administration; and Dr. Arne Schulerud of the Statens Teknologiske Institutt of Oslo, Norway.

The Guest Speakers

Dr. King will be returning from India to address the Association on "The importance of cereals in human nutrition, with special emphasis on present-day India." An eminent authority in the field of nutrition, he has traveled widely and, like Dr. Miller, is well qualified to comment on problems besetting the free world as a

result of poor nutritional standards in many areas. His activities and achievements include his work with the Nutrition Foundation, where he has been Executive Director since 1955 and was Scientific Director from 1942 to 1955. Dr. King is a member of the National Academy of Sciences; the Agricultural Research Policy Committee of the U. S. Department of Agriculture; the Food and Nutrition Board of the National Research Council; he is the recipient of the Nicholas Appert Award for 1955, the John Scott Award for 1949, the Scientific Award of the Grocery Manufacturers of America for 1944, and the Pittsburgh Award of the American Chemical Society for 1943.

Dr. Glen G. King, Scientific Director, Nutrition Foundation, New York. As a leading authority on human nutrition, Dr. King will address the A.A.C.C. members on the importance of cereals in the diet, with particular reference to present-day India.

Dr. Miller has served as visiting lecturer at the Harvard Graduate School of Business Administration since 1948. For the past eight years, until January of 1956, he was consultant to the Director General of the Food and Agriculture Organization of the United Nations (FAO). In this connection he has spent much of his time overseas, and is on intimate conversational terms with heads of states and ambassadors of many nations in the Far East, the Middle East, and South America. He is a

Dr. Raymond W. Miller, Visiting Lecturer, Graduate School of Business Administration, Harvard University. Dr. Miller will appear as guest speaker on the opening session of the A.A.C.C. meeting.

Trustee of the Transportation Association of America, a member of the Board of Trustees of the American University, and formerly President of the American Institute of Cooperation. Dr. Miller is author of several books and numerous articles on agriculture, business, public relations, and international affairs. He is considered an authority on the international aspects of food and nutrition and is well known for his insight into the human aspects involved in the solution of world food problems. He and Dr. King have long been personally acquainted as a result of their mutual interest in the relatively new science of human nutrition. Their joint appearance on the program promises an interesting and stimulating session.

Dr. Arne Schulerud will present interesting information and data on the subject of flour and baking in Scandinavia. Appearing on the program at other times will be several well-known foreign scientists from Australia, Canada, England, Germany, and Sweden.

Come and Be Entertained

In the best Knickerbocker tradition, the New York Section as host for the meeting is striving to ensure that A.A.C.C. members and their families will enjoy their stay in the "big town." Aside from its fine accommodations and service, the Commodore Hotel was chosen for the meeting site to provide the most convenient central location for relaxation as well as for the business at hand.

Well known to many is the Commodore's all-weather location, along with several other near-by popular hotels which may accommodate some of the group. There are inside connections from the hotel to Grand Central Station, Penn Station, and the entire subway network. Taxis and buses to all points are immediately at hand, but many attractions are located within a few blocks of the hotel. All within easy walking distance are four of "New York's Favorite Five" — definite favorites for the city's 13,000,000 visitors each year according to statistics compiled by the New York Convention and Visitors' Bureau. These are: the city-within-a-city known as Rockefeller Center; the 72-year-old Statue of Liberty; the 1,472-foot Empire State Building; the relatively new United Nations Headquarters; and colorful Times Square. Though Miss Liberty, "America's number one glamour girl," is a bit out of reach from the Commodore if you walk or swim, there are the conventional approaches via subway, boat tour, and ferry. Again at the Commodore, one finds many of the best shops and stores close at hand on Fifth, Park, and Madison Avenues. Literally dozens of world-famous restaurants and clubs dot the area.

Planned for the Ladies

An active and interesting ladies' program has been planned with an eye to the fact that many of the ladies will wish to take full advantage of this splendid opportunity for shopping and sightseeing. Chairman for

Ladies' Entertainment Committee. Seated, l. to r.: Mrs. C. L. Brooke, Mrs. W. H. Cathcart, Mrs. E. K. Spotts; standing, l. to r.: Mrs. George Hill, Mrs. Paul Snell, Mrs. Gaston Dalby. Members of the committee not shown are Mrs. E. T. Palomba, Mrs. Henry Favor, and Mrs. Lloyd Crossland.

the Ladies' Program, Mrs. Gaston Dalby, assisted by hostesses from the New York Section, will be on hand to accompany or direct the ladies to their destinations. Here are some of the highlights as reported by Mrs. Dalby: A tour of the *Daily News* Building, the newspaper with the largest circulation in the country; a Breakfast and Decorator Show — courtesy of Sterwin Chemicals, Inc. — at B. Altman's, one of New York's largest department stores; Wallace and Tiernan will be hosts at a Luncheon and Fashion Show to be held in the famous Hawaiian Room of the Hotel Lexington; a tour of the United Nations Headquarters will include a luncheon to be held in the impressive Secretariat's dining room overlooking the East River.

New York Convention and Visitors' Bureau, located at Pershing Square, 90 East 42nd Street. The Bureau is opposite Grand Central Terminal and the convention hotel (Commodore). A.A.C.C. convention-goers are urged to make use of the bureau's many courtesies for visitors, including free maps, list of popular restaurants, theaters, etc. The center is open every day of the week. Photo courtesy New York Convention and Visitors' Bureau.

Old and New in New York

Your reporter has admittedly sidestepped the staggering task of composing the usual write-up on a convention city, such as would do justice to New York. Since this is so much "everyman's town," perhaps it can safely be assumed that most of the membership have kept abreast of the many changes which have occurred since our last visit in 1949. If not, there are a few surprises in store. For example, the sun shines brightly on Third Avenue, where the old Third Avenue El has been dismantled and hauled away for scrap. Many visitors have marveled at the comparatively new all-glass exterior of Lever House on Park Avenue; not so many have seen the latest glass-, stainless steel-, and aluminum-paneled structures just completed or in process of construction and destined to join the list of familiar New York landmarks.

The city's new Coliseum at Columbus Circle will have just opened for business by meeting time, providing more than 301,000 square feet of unobstructed space in the world's most modern exhibition hall. Other futuristic structures are the new glass block house of the Colgate Company on Park Avenue, the new *Look* Magazine Building on Madison Avenue, and the unique all-glass-and-aluminum building of the Manufacturers' Trust Company at Fifth Avenue and 43rd Street. Here the bank's huge thirty-ton vault door is viewed from the sidewalk on Fifth Avenue through an uninterrupted display window extending the full length of the front of the structure. Inside, traditional bank activities are carried out in an untraditional atmosphere over counters free of bars or grillwork. Another man-made mountain of glass and stainless steel is rising forty-five stories above the south side of 42nd Street between Lexington and Third Avenues. This will be the new Socony-Mobil Building, the sixth biggest office building in the world. Incorporating today's most advanced technological developments, it will be the largest fully air-conditioned commercial structure ever built. There will be no operators to run its thirty-

United Nations General Assembly and Secretariat Buildings. Over 3,500 international civil servants are employed in the Secretariat Building, which has more than 5,400 windows. East River with Queensborough Bridge in background. Photo, N. Y. Convention Bureau.

A.A.C.C. President Cathcart discusses plans for coming convention with local arrangements committeemen. Left to right, W. H. Cathcart; Gaston Dalby, Technical Program Chairman; Ric Palomba, Local Arrangements Chairman; and Zenas Block, Program Committeeman.

three passenger and three freight elevators, since electronic "brains" will regulate the movement of all cars in direct proportion to the traffic. This and some eighty or more other major building projects are available for those experienced "sidewalk engineers" who wish to take this opportunity to pick up a few credits toward advanced degrees.

Baseball fans will hardly need to be reminded that the season will be well under way by meeting time. It is universally known that here are the famous battlegrounds of the Dodgers, the Giants, and the Yankees. Repeating our theme, there is easy access to all three stadiums — Ebbitts Field, the Polo Grounds, and Yankee Stadium.

The New York Convention and Visitors' Bureau, conveniently located opposite the Commodore Hotel at 90 East 42nd Street (New York 17), publishes a number of helpful folders, maps, and guides, all available for the asking. An excellent and well-marked tourist map of Manhattan shows locations of theaters and other major attractions. There are church and restaurant guides; information on tours, both on land and by boat; and the current schedule of seasonal events. Anyone planning to visit New York is urged to write in for a set of these valuable aids, or to drop in at the Bureau to pick up copies personally and obtain other helpful information and advice.

Several industrial tours have been organized. So far these include Hoffmann-La Roche of Nutley, New Jersey; Chas. Pfizer & Co., of Brooklyn, N. Y.; and Merck & Co., of Rahway, New Jersey. The host companies will arrange transportation and luncheon for those desiring to make these visits.

All in all, the 41st annual meeting promises to be bigger and better than ever. Here is an opportunity for cereal chemists, nutritionists, and all others interested in food and nutrition to attend an unusually well oriented program in the business and recreational capital of the East, New York City. Come, and give your New York hosts the chance to prove to you and your family that New York deserves the description of friendly vacation city as well as the title of the world's largest metropolis.

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. . . People

Don Abbott, formerly connected with the U.S.D.A. Soft Wheat Quality Laboratory, Wooster, Ohio, is directing the new Milling and Baking Laboratory at Oklahoma A&M College, Stillwater.

J. A. Anderson leaves for the United Kingdom and Europe early in May to tour the principal European cereal laboratories. The tour will terminate June 23-30 at St. Andrews Cereals Symposium, sponsored by the Royal Institute of Chemistry, where Dr. Anderson is to present a paper entitled "The Canadian chemist's role in breeding grain varieties of high quality."

Zenas Block named vp in charge of planning and research, Doughnut Corporation of America.

William T. Brady elected president and chief executive officer of Corn Products Refining Co. Succeeds **E. W. Reid,** now chairman of the board.

S. L. Chen appointed senior scientist at Red Star Yeast and Products Co., Milwaukee. **J. R. Helbert** named to newly established position of field representative for research. **Robert L. Mueller** named assistant to the director, fermentation lab. **D. W. Penn** assigned temporarily to Pan American Red Star Yeast and Products. **Robert S. Yare** named director of biochemistry lab in Milwaukee, and **John A. Thorn,** director of cereal chemistry lab.

Charles G. Ferrari, technical director of the J. R. Short Milling Co., Chicago, has been elected a vice president of the company. Dr. Ferrari has been Managing Editor of *Cereal Chemistry* and a member of the A.A.C.C. Executive Committee.

Thomas L. Gresham resigns as director of organic chemicals and engineering research for B. F. Goodrich to become vp-research and development for A. E. Staley Mfg. Co., Decatur, Ill.

Stanley Herman, formerly of Carnation Research Laboratories, now with Procter & Gamble at Ivorydale.

C. M. Hollenbeck resigns from Merck & Co., Inc., on May 1 to join Wisconsin Malting Co., Manitowoc, Wisconsin, as director of research.

Robert P. Joslin, former senior research chemist for Monsanto Chemical Co., appointed product research manager for Fairmont Foods Co., 3201 Farnam, Omaha, Nebraska.

Lowell R. Patton, Jr., formerly in charge of sale operations in the Buffalo area for Sterwin Chemicals Inc., now assistant sales manager at New York headquarters under **William X. Clark,** vp in charge of sales Mr. Patton will supervise sales to the milling and baking industries. He is former chairman and member of executive committee of the Niagara Frontier Section, A.A.C.C.

Chester C. Robinson, sales manager of the vitamin division of Hoffmann-La Roche, Inc., died on Sunday, March 25, following a cerebral hemorrhage. Mr. Robinson had been associated with Hoffmann-La Roche since 1941 and was well known throughout the pharmaceutical, fine chemical, and food industries.

Roland W. Selman, 40, President R. W. Selman and Associates, Inc., St. Louis, Mo., died April 2 at St. John's Hospital, St. Louis, after an illness of several weeks.

Mr. Selman had been extremely active in Association affairs from the time he joined in 1940. During the past year he had been Chairman of the Amylograph Standardization Committee. He received his B.S. degree from the University of Chattanooga in 1938, and continued with graduate work at the universities of Kansas City, Wisconsin, and Pittsburgh. Mr. Selman was employed as an analyst at the Campbell-Taggart Research Corporation; served as an industrial fellow at the Mellon Institute of Industrial Research; and as director of research and control, baking laboratory activities, C. J. Patterson Co., Kansas City, 1944-46, and as vice-president 1946-1950. In 1950 Mr. Selman moved to St. Louis and established his own consulting firm for bakeries. Among the many other organizations in which he was active were the Institute of Food Technologists and the American Chemical Society.

Jim Thomson of Pillsbury Mills leaves the Los Angeles branch to join the Minneapolis staff.

S. N. Vilm of El Reno, Oklahoma, now with Producers Grain Company in Amarillo, Texas.

Edward R. Weidlein has retired as president of the Mellon Institute of Industrial Research in Pittsburgh. He was feted in the latter part of March at a testimonial dinner. Dr. Weidlein had been actively identified with the Institute for over 40 years.

Robert S. Whiteside elected president of Sterwin Chemicals. **Reginald C. Sherwood** named vp and technical director and **William X. Clark,** vp sales. Whiteside formerly vp, succeeds the late **P. Val Kolb.**

. . . **Patter**

The American Society of Brewing Chemists will hold their 1956 convention in St. Louis May 6 to May 10. Program Committee Chairman Philip D. Gray advises that a wide variety of interesting topics pertinent to brewing chemistry and technology is in prospect. Among subjects up for discussion are melanoidins in brewing, determination of hop bitters and their significance in beer, and studies on oxalates. Important analytical techniques will also be considered. The barley and malt program will include discussions of criteria of malting and brewing quality for new varieties by both American and Canadian authorities. An outstanding feature will be a general session Wednesday afternoon in which the present state of knowledge of the "trinity" of brewing materials — malt, hops, and yeast — will be reviewed in an extended paper, each by an authority in his field. Local convention chairman Joseph E. McClary of Anheuser-Busch has promised an entertaining and enjoyable social program for the entire meeting.

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The newly installed Milling and Baking Laboratory in the Small Grains Research Building at Oklahoma A&M College, Stillwater, was dedicated on February 28. The dedication ceremony was a part of the Fifth Annual Wheat Institute held here.

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Cerealists from the United States and Canada met in Winnipeg February 16-17 for the Barley and Oil Seeds Conference, following the meetings of the Associate Committee on Grain Research.

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Housewives shouldn't expect to go to market and buy meat that will never spoil, potatoes that will never sprout, or artificially flavored food that tastes exactly like the real thing. Science hasn't solved all the problems yet. This was brought out at a gathering of over 100 scientists from as far away as South Africa who convened in San Antonio March 15-16 to discuss the latest advances in the selection, handling, and processing of food. The meeting was sponsored by the Institute of Food Technologists and Southwest Research Institute. I. Hlynka of the Grain Research Laboratory, Winnipeg, A.A.C.C. member, spoke on "The application of physics to studies of breadmaking quality of wheat." Ernest W. Reid, chairman of the board of Corn Products Refining Co., said that while one-third of the consumer's dollar goes for the purchase of food, only approximately 8% of the chemists in America are engaged in the food industry and the percentage of physicists is much smaller. He called for a program which would bring more scientists to all phases of food research and more students into undergraduate programs in chemistry, physics, food technology, and allied subjects. Copies of the proceedings are available from Southwest Research Institute for $5.00. Address C. W. Smith, 8500 Culebra Road, San Antonio.

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The best articles from European technical and industrial journals, translated and digested, are now available monthly to American industry, John C. Green, Director, Office of Technical Services, U. S. Department of Commerce, announces. The Organization for European Economic Cooperation, a multi-government agency set up to stimulate economic growth of member-nations, will distribute its monthly publication *Technical Digests* in the United States. It is designed primarily for those interested in manufacturing and production. Many of the articles in the periodical, which averages 140 illustrated pages, discuss new products and processes developed by European manufacturers. Designed for clear, concise, easy reading, the magazine contains digests of only the most effective articles gleaned by specialists from over 1,000 European periodicals. Subscriptions are handled by O.E.E.C. Mission Publications Office, 2000 P Street, N.W., Washington 6. The rates are $24 a year or $2.50 per single issue.

Editor's Note. News items concerning individuals, products, services, equipment, meetings, etc., pertinent to the field covered by *This Journal*, will be considered for publication and should be addressed to: News Editor, *Cereal Science Today*, University Farm, St. Paul 1, Minn.

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the President's Corner

news of the association

I am proud to have this new A.A.C.C. publication, *Cereal Science Today*, become a reality during my administration and to commend to you those devoted members who made it a reality.

This first issue of *Cereal Science Today* and those which will follow have something of interest for every one of its readers. There will be ten issues of *Cereal Science Today* each year with the months of June and August being omitted. It is your publication and I urge all the membership to contribute to its many features.

I hope you are all planning to come to New York City to attend our 41st Annual Meeting which will be held at the Commodore Hotel, May 20-24, 1956.

Local Arrangements Chairman, Mr. E. T. Palomba, has obtained excellent accommodations for the meeting and also for our members and the guests of the A.A.C.C.

Program Chairman Mr. Gaston Dalby has organized a well-balanced program which promises both information and inspiration, while the social side of the meeting will provide fellowship and pleasant recollections. I urge all of you to come.

Several years ago the Executive Committee considered the incorporation of our Association. Under the capable Chairmanship of R. C. Sherwood, the Committee on Revision of the Constitution has prepared a new proposed document necessitated by the Executive Committee's recommendation that the Association incorporate as a non-profit corporation in the State of Minnesota. This document, which is proposed to replace the present A.A.C.C. Constitution, will be voted on by the membership at this year's Annual Meeting. Because of the requirements of the Minnesota Non-Profit Corporation law it is quite different in form from our present Constitution but not in content. It consists of Articles of Incorporation supplemented by a group of By-Laws which detail the operating rules of the incorporated Association. These By-Laws are essentially the same as our present Constitution. Provision has been made to add resolutions if it is so desired. Such resolutions would be decisions made by past Executive Committees and future Boards of Directors, having guidance value to the Association.

The proposed Articles of Incorporation and By-Laws have been approved by your present Executive Committee, which has unanimously recommended that the membership adopt them at this year's Annual Meeting.

W. H. CATHCART

Swift & Company Congratulates "Cereal Science Today" on its first issue published

TO YOU, the reader, Swift & Company's General Refinery Department, and Research Laboratory, offers the most complete shortening service in the industry. Swift & Company has a shortening product for every requirement.

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BOOK reviews

The Technical Report — Its Preparation, Processing, and Use in Industry and Government, edited by B. H. Weil; 90 illustrations; 415 pages plus 2 appendixes, author and subject indexes. Reinhold Publishing Corp., New York, 1954. Price, $12. Reviewed by EUNICE R. BROWN, This Journal.

Here is a book on the "quality control" of technical papers and reports. The talents, skills, and experience of 23 experts in technical writing are combined to bring the beginning writer in almost any field of science all the help he needs or can use, short of personal guidance. For the experienced writer there is information to broaden his approach to most writing assignments; for the editor there is much to take the edge off occasional dullness and drudgery. The "technical" tag need not scare anyone away if he has no intention of writing technical reports. Several chapters, at least, are packed with generally useful and helpful information. In particular, these might be Chapter 3, "Writing the technical progress report"; Chapter 4, "Writing the formal technical report"; and Chapter 5, "Common faults and recommended practice in writing technical reports." The "factors involved in good clear writing" are explained, by more than one of the authors, concisely and vigorously, with examples of "do's" and "don't's" in terms that have a familiar ring to the cereal chemist. Abscissas, Baume, desiccator, homogeneous, pipet, Soxhlet, and viscometer (preferable to viscosimeter) appear among the "words frequently misspelled" (Chapter 5). There is much more of value in this chapter, including a section on inexact expressions, with a hilarious example or two to help the patient swallow the pill if the usual ones sound painfully like his own phrases. The "amusing essay" entitled "Splitting the infinitive" is a gem. In Chapter 3, a pitfall the author wishes we would all avoid is that of employing the "high polymer" adjective, of which he gives this extreme example: single rotor helicopter rotor blade tip angle. (Puzzle: find the noun being modified. You can tell it only because it comes last.)

There is much useful information in the chapters mentioned above and in following ones: Chapter 6, "Writing the literary summary," has much help for a none-too-easy task. In Chapter 7, "The oral report, its preparation and presentation," suggestions are given on overcoming nervousness and making a pleasing delivery, rehearsing, and handling audience discussion. There is a check list covering important things to be seen to. Chapter 8, "Editing the technical report," is useful not only for the editor himself but for helping the writer put himself in the other fellow's shoes (or his office chair). Chapter 10, "Illustrating, duplicating, and binding," points out the "relationship of the report writer to the graphic-arts group and its methods and equipment," with many illustrations and helpful information on preparation of graphs, suitable drawings, and photographs — "ways in which the writer can ensure the quality appearance of his reports." Chapter 11, "Making graphs and tables more effective," has suggestions on what to do and what to avoid — and here much material is quoted from an article familiar to cereal chemists, by an A.A.C.C. member. Indeed, names of chemists and chemical engineers are prominent among both the authors and the literature citations — which, incidentally, are profuse.

Other chapters are valuable in more specialized fields: editing, style manuals, distribution, filing, classifying, and indexing. Considering together the text and the voluminous references, the book gives ample material for a variety of purposes, from convenient help in occasional writing to a complete study course leading to a well-rounded and well-qualified career.

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College Chemistry. An Introductory Textbook of General Chemistry, 2nd ed., by L. Pauling; xii + 685 pp. W. H. Freeman and Co., San Francisco, 1955. Price $6.00. Reviewed by W. F. GEDDES, University of Minnesota.

The present book comprises the second edition of the well-known text published by Pauling in 1950. It presents a gradual, systematic, and logical introduction to the facts, concepts, and theories of chemistry through its arrangement into six parts: Part I, an introduction to modern chemistry; Part II, some aspects of chemical theory; Part III, some nonmetallic elements and their compounds; Part IV, water, solutions, and chemical equilibrium; Part V, metals and alloys and the compounds of metals; and Part VI, organic chemistry, biochemistry, and nuclear chemistry. A new chapter, dealing with the electron and the nuclei of atoms is included in Part I; it is designed to aid the student in understanding the electron theory of molecular structure upon which modern chemistry is based. The present volume contains excellent chapters on organic chemistry and biochemistry. It is well illustrated with diagrams of chemical apparatus.

The book is written in a clear, fascinating style and should be on every chemist's book shelf as a ready source of information in descriptive chemistry and modern chemical theory.

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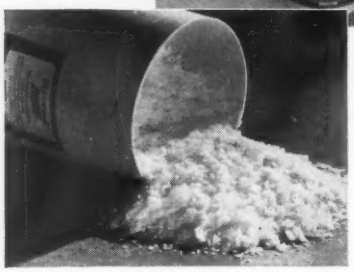

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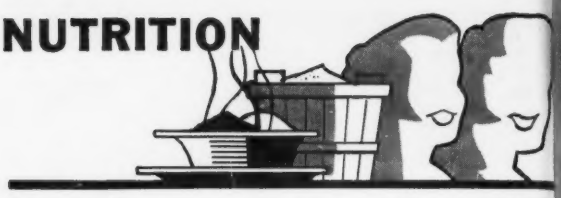

W. B. Bradley **Clinton L. Brook**

USE OF RADIOACTIVE IRON REVEALS VALUE OF ENRICHMENT

The use of radioactive tracers in studies involving human metabolism has added materially to our knowledge of the availability and fate of individual nutrients. Of particular interest to the cereal industry are the studies of Steinkamp, Dubach, and Moore, which demonstrated that various forms of iron used in cereal enrichment when baked into bread, were equally well utilized by both normal and anemic subjects.

The study also revealed that the iron of enriched bread was as available for absorption as the iron of liver and other recognized good food sources of this element. The data reported by these investigators answers the argument made by some writers that iron enrichment of cereal products lacks merit because some of the types of iron commonly employed cannot be absorbed from the human gastrointestinal tract and made available for hemoglobin synthesis.

Ferrous sulfate, reduced iron, ferric orthophosphate, and sodium ferric pyrophosphate, made from radioactive iron (Fe^{59}), were baked into enriched bread using a formula and processing methods which simulated commercial bread manufacture. These breads containing "tagged" iron were fed to 26 normal male and six female adults, and to three patients with hypochromic microcytic anemia. Unabsorbed radioactivity in the feces of all subjects was measured. Radioactivity of the circulating blood was used as a measure of newly synthesized hemoglobin.

It was found that, regardless of the form of iron used in the enrichment mixture, normal individuals absorbed and utilized between 1 and 12% of the total iron fed. Four subjects, who were suspected of having suboptimal iron stores, assimilated from 26 to 38% of the Fe^{59}. Administration of ascorbic acid along with the bread increased the absorption and utilization of the iron. The anemic patients absorbed and utilized 45 to 64% of the ferrous sulfate, ferric orthophosphate, and sodium ferric pyrophosphate.

This utilization of iron from enriched bread compares favorably with the utilization of iron from eggs, liver, muscle meat, and leafy vegetables previously determined by the same investigators using the radioactive iron techniques. Normal individuals absorbed and utilized 4 to 9.4% of the iron from these food sources. Anemic patients failed to utilize iron from these food sources more efficiently, as they did when enriched bread was the iron source.

W. B. BRADLEY

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CEREAL SCIENCE today

Technical Section

May 1956 Volume 1 • Number 1

The Meaning of Commonly Quoted Analytical Values of Shortenings as Related to Shortening Performance
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THE MEANING OF COMMONLY QUOTED ANALYTICAL VALUES OF SHORTENINGS AS RELATED TO SHORTENING PERFORMANCE[1]

D. V. STINGLEY AND F. G. WHEELER, Research Division, Armour and Company, Chicago, Illinois

NUMEROUS CHEMICAL AND physical tests are employed in the manufacture of shortenings to control quality at all stages of processing, from raw materials to finished product. Many consumers have also adopted various chemical and physical constants as a part of the specifications governing their purchases of shortening. Since the manufacturer employs these tests in making shortening, the consumer feels, with some justification, that in adopting them as a part of his specifications he is assuring himself a shortening with the performance characteristics he desires. This, unfortunately, is true only in part, since many tests employed by the shortening manufacturer give no indication of finished shortening performance. However, they do serve as necessary guideposts in processing operations.

Some of the various chemical and physical constants of a shortening, as determined in the laboratory, can be translated by an experienced operator into approximate terms of shortening performance, but in order to actually prove what a shortening will do, performance tests are required. This, then, raises two questions. First, why is it necessary for the shortening manufacturer to perform the numerous tests he runs? Second, what requirements can the consumer write into his specifications in order to obtain the consistent shortening performance he desires?

Answering the first of these questions is a relatively simple matter. The manufacturer tests his raw materials to confirm their identity and to maintain uniformity. Then at each processing step additional tests are made to control refining, hydrogenation, deodorization, and other processing steps. All of these controls, coupled with the final tests on the finished product, assure him that each production lot conforms to established standards. In other words, when a satisfactory shortening formulation has been developed, the manufacturer's tests are designed to control duplication of the product.

The second question is more difficult to answer: How can the consumer write specifications to assure himself of obtaining a product with the performance characteristics he desires? Some twenty or more recognized tests are employed in production control, in research, and for evaluation of edible fat products. Some are standardized tests such as those recognized by the American Oil Chemists' Society, The American Society for Testing Materials, and other professional groups. Detailed instructions on some of the tests which follow can be found in the latest edition of *Cereal Laboratory Methods* (1). Additional tests, particularly performance tests, have been devised by individual laboratories to meet their specific requirements. Other techniques, especially those employed in research work, and some tests rather generally used in control work, are available only from the literature.

It is important to remember that analytical and testing procedures are not static but are constantly being investigated and improved. New methods are not accepted as standard procedures until they have been thoroughly tested.

We will discuss first a series of methods which are in general use in the shortening industry.

Free Fatty Acids

The determination of free fatty acids (1) is the method used to measure the acidity of fats and oils generally. Results are expressed in percent free fatty acid

[1] Manuscript received June 13, 1955.

(FFA) as oleic acid, and a shortening with not more than 0.10% FFA is generally acceptable for most shortening uses. Many shortenings actually run well under this figure, although certain special types may be somewhat higher. In general, excessive amounts of free fatty acids are undesirable since they can contribute to poor flavor and rancidity if the shortening is held for long periods of time. A high FFA content also lowers the smoke point, and in deep-fat frying a rise in free fatty acids from 0.1% to 1.0% lowers the smoke point from approximately 410°F. to under 320°F. This is the reason operators of deep-fat frying equipment often control their operations by the use of this test.

Color

Wesson Method — Lovibond Standard Glasses (2). The color of shortenings is determined on a melted sample of the fat and is expressed in yellow and red units, or possibly red units only. Color alone is not a criterion of shortening quality. Even though we have come to associate whiteness with purity, this largely is an educated habit which could be changed to yellowness and purity or some other color, depending upon future developments. The maximum color permitted on many shortening products is 20.0 yellow and 2.0 red. A permissible color for a given end use is actually a matter of preference. In most cases, the color does not materially affect the color of the finished baked foods.

Iodine Value

Wijs Method (1). The Iodine Value or Number is a measure of the degree of unsaturation of a fat. Refractive Index is another way of obtaining very similar information, and for our discussion these tests can be considered identical without causing confusion. Iodine value is useful in identifying and characterizing crude fats and oils. In shortening manufacture its main utility is in the control of hydrogenating operations to assure uniformity of product. To some extent, iodine value is a measure of the softness or hardness of a fat, since oils high in iodine value are liquid, while fats with low iodine values are hard waxy solids. This is not the entire story, however, since hardness and brittleness for a material of given iodine value can also be varied by the type of hydrogenating conditions employed. To the consumer, iodine value alone will have little meaning in his specification unless he knows, for example, that a cottonseed oil, hydrogenated to a given iodine value and Wiley melting point, gives him the performance he desires. In this case, a specification written to include the base oil, iodine value, and Wiley melting point will assure the user a uniform product. There is, however, an economic objection to this type of specification, since it limits the manufacturer to one type of oil, whereas a specification based on performance would permit a wider selection and the user would benefit economically since his product could be made from the most favorably priced raw materials.

Wiley Melting Point

Because fats are polymorphic substances consisti of diverse mixtures of triglycerides, a true melting poi such as that obtained when ice melts to form water, do not exist. Wiley Melting Point (1) is a specific standar ized method for obtaining reproducible results. It is, in way, the measure of the hardness of a given shortenin but by itself gives practically no information as to th texture or performance characteristics of the fat. Fo example, a candy-coating fat with a Wiley melting poi of 38°C. is a hard, brittle, sharp-melting material, where as a properly formulated, all-purpose shortening with th same Wiley melting point is a soft-textured, plastic pro uct. In a like manner, the Capillary Melting Point Meth od (1), which gives results slightly higher than Wile Melting Point, is of limited usefulness.

The laboratory methods of both the American Asso ciation of Cereal Chemists and the American Oil Chem ists' Society list a considerable number of other specia ized tests. Those we have discussed are the ones mos commonly employed and of the greatest interest in th shortening field. Unfortunately, no standardized pro cedures are available for many other useful tests, a though some, such as the methods of infrared and ultra violet spectrophotometry, X-ray diffraction, and variou basic research procedures not applicable to this discus sion, are available from the literature. This applies als to dilatometry, although a special committee of the Ameri can Oil Chemists' Society is now at work attempting t select and standardize the most satisfactory procedure fo this determination. Dilatometry, which is a method t determine the ratio of hard fats to liquid fats in a short ening at a series of selected temperatures such as 50° 70°, 92°, and 104°F., is a relatively new procedure. It i definitely one of the most valuable research tools availabl for the study of shortenings, but it does not solve th question of shortening performance and it tells very litt more about texture and plasticity than can be determine by a simple penetrometer test.

Various analytical procedures such as the determina tion of the percent monoglyceride and free glycerol, quali tative tests for antioxidants, peroxide value, congeal point quantitative and qualitative tests for trace metals, soa content, etc., are all procedures that the analyst in an producer's laboratory must be prepared to perform eve though, again, many of these methods may not appea in the standard handbooks and would not necesarily b of value to the user of the finished shortening.

In our experience we have found no simple, eas answer to shortening evaluation other than the tests w are about to discuss. These tests, which are either physi cal or performance tests, are often not so precise as coul be desired and almost all of them could be improved b further study and standardization. While these tests ar empirical in nature they have the advantage of bein simple, practical determinations which give very prac tical results in terms that are understandable by technica

and nontechnical workers alike.

Stability and Flavor

One of the major concerns of the users of shortening is the problem of stability or the resistance of the shortening to undesirable changes, resulting in rancidity and flavor reversion. These changes may occur in storage, in use, or in the finished product, which might be anything from conventional baked goods to frozen pastries and packaged premixes. A great deal of attention has been given to this problem, and a number of reasonably satisfactory procedures have been developed to evaluate various phases of stability.

Active Oxygen Method

As a test for oxidative deterioration resulting in rancidity, the active oxygen method (1) is commonly employed and the results, reported as A.O.M. hours, reliably indicate the resistance of the shortening to oxidation. Various modifications of this method are employed, such as running the test at 110° instead of 97.7°C. The higher temperature decreases the time to obtain results to about one-fourth of that at 97.7°. Standards varying from 50 to 100 hours, depending upon the type of product and end use, adequately ensure against difficulty from this source.

A much more serious problem is instability causing undesirable odors or flavors, commonly known as flavor reversion. In vegetable fats this would probably be referred to as a "beany" or "green" odor; in meat fats the terms "lardy" or "tallowy" might apply. Unfortunately, this difficulty can occur with all edible fats and oils regardless of source, and the manufacturer of shortenings takes extreme precaution in his processing to safeguard the flavor and odor of his products. Almost all manufacturers employ some version of the flavor panel or odor panel in judging flavor and odor. An accelerated aging test has been developed, in which samples of shortenings are held at elevated temperatures for stated intervals of time. The flavor and peroxide value resulting from this treatment then serve as an index of the life expectancy of the shortening.

No matter how many chemical and physical tests we conduct on a shortening, the entire story can be known only from actual performance tests. Therefore, in order to find out just how products behave in actual use, accelerated storage tests on various finished baked goods such as crackers and cookies help determine shelf life and assist in drawing conclusions regarding the over-all stability of a given shortening.

In the matter of texture, it is practically impossible to find any true "black-and-white" standards that can be applied. The A.S.T.M. penetrometer gives some data on the plastic range of a shortening and will indicate how soft or hard it is at a given temperature. The hand and eye still must decide whether or not the shortening is "sticky," "waxy," "grainy," "rubbery," or "lumpy," with the result that these terms must be employed. Actually, we see no alternative to this practice, and while the possibility of misinterpretation "in degree" does exist, this can be quickly eliminated once a standard texture is agreed upon.

Performance Testing

With shortenings as with many other products, the final criterion is whether or not they work properly in a given application, and, short of making actual plant-scale test runs, performance tests give the most satisfactory answers. These tests, which include icing volume, pound-cake volume, layer-cake volume, and other baking tests, are designed to evaluate by practical application the properties of a shortening for a given use. In general, simple representative formulas are employed and the test procedure is standardized to eliminate variables to the greatest extent possible. Results are evaluated in various ways, but the method of reporting is not important so long as the detailed procedure is known. Cake volumes are frequently reported in cc/100 g, but cc/g or total cake volumes could serve just as well, and some people prefer to report in this manner.

All commercial shortenings are mixtures of many different triglycerides, each with a distinctive composition, melting point, and congeal point. The proportionate amount of each of these individual triglycerides has considerable influence on the finished shortening. But because shortenings are crystalline in nature and because crystals vary in size depending on the speed of formation, variations in the physical condition of the shortening are possible with products of identical chemical composition. Tempering and storage conditions as well as conditions of use can alter the physical properties of plastic fats, so that shortenings of identical chemical composition will act differently. Because of these conditions it has been our experience that the most reliable tests are those which most nearly simulate actual use conditions.

If the shortening is to be used in cakes where the process demands that a certain amount of air be incorporated into the batter, cakes having this requirement for their successful production should be baked; a lean pound cake containing no chemical leavening is the usual choice. If the air incorporation must be accomplished in a certain length of time, time limits should be established on this phase of the test. Standards of performance may be established on finished cake volume or on specific gravity of the mix, or may include both determinations. Most of the performance tests have been designed to ensure proper functioning of the shortening in specific jobs.

Pound Cake Tests

The pound cake test (1) indicates whether or not a shortening has the ability to become aerated when it is agitated. It further indicates whether or not shortening will retain this air in the presence of moisture. In the usual pound cake tests no chemical leavening is used, and the incorporated air is essential for good cake volume.

Wet Creaming Volume

The wet creaming volume[2] measures the same factors as the pound cake test. The volume of the cream can be used as a measure of baking performance when air incorporation is necessary.

Icing Volume Test

Icing volume[2] measures these same factors, although frequently other characteristics are taken into consideration. It is sometimes desirable for a shortening to produce an icing with a greater amount of moisture than that normally used. This calls for water-retaining properties as well as air incorporation.

An icing volume determination is recommended for high-absorption shortenings, because much of this shortening is used in icings and the making of a good cake does not ensure a good icing, or vice versa.

Layer Cake Test

The 140% sugar, white layer cake test[2] is used to evaluate high-absorption cake shortenings; 140% sugar is used because this places the greatest burden upon the shortening. White cakes cause more trouble than yellow or devil's food cakes; hence a white layer cake evaluation on a high-absorption shortening usually ensures its performance in all normal baking uses.

Water Absorption

Another test made on high-absorption shortenings is that of water absorption[2], which is a measure of the ability of the shortening to emulsify with water. The authors have been unable to find a practical application of this test. A high water absorption does not mean that more moisture can be added to cake batters or icings, neither does it indicate a good baking performance. Extra high water-absorption values usually result in low icing volumes.

Dry Creaming Volume

Dry creaming volume tests[2] on shortenings indicate an ability on the part of the shortening to take on air when it is mixed with sugar. This ability is necessary in shortenings which are to be used in baking operations requiring air incorporation, and a shortening lacking this ability will not function properly in the baking operation. The fact that a shortening will take on air when mixed with sugar, however, does not guarantee good performance in baking, as many fats will take on air when mixed with sugar but will not retain it when moisture is added. The wet creaming volume seems to be a much better test.

[2]Armour and Company; unpublished work.

Prepared Mix Tests

For prepared mix work, the shortening is usually incorporated into the mix for which it is designed, and actual baking tests are then made under simulated home conditions. In the prepared mix field it seems that a special shortening is required for each type of mix manufactured, white, yellow, and devil's food cakes each requiring slightly different amounts and formulations of shortening. In addition, each manufacturer has standards somewhat different from those of his competitors, with the result that each requires his own set of performance tests.

The baking industry has probably more problems with regard to the uniformity of its raw materials than any other group. Its members employ many natural products which by their very nature are greatly influenced by drought and flood, the soil in which they grow, and all the other variables that can occur.

We are still a long way from standardizing nature, but certainly major accomplishments have been made in processing natural raw materials to give uniform end products. The shortening manufacturer may someday be able to produce a universal shortening, but today it seems more probable that we are entering an era of "tailor-made" shortenings designed to give maximum performance in a given area of use. If this is true, future shortening specifications will undoubtedly be written around specific performance tests designed to give desired results.

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MINERALS IN MANUFACTURED FEEDS[1]

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THIS PAPER WILL consider some of the more important problems of mineral nutrition in the formulation and manufacture of animal feeds. Research problems of current interest to nutritionists will be examined in some detail. However, the discussion will not include quantitative requirements of various classes of animals for different minerals, nor the general biochemical functions of the essential minerals.

Essential Mineral Elements

Among chemical substances required for the nourishment of both man and animals fourteen elements, commonly classed as minerals, are believed to be absolutely essential. These elements occur mainly in the inorganic or mineral state, and most of them are supplied preferably in that form. For two elements, sulfur and cobalt, it is generally more effective to supply the organic compounds which are metabolized by the body; nevertheless, nutritional parlance has firmly established these two elements in the category of minerals.

Evidence of essentiality is rather conclusive for the mineral elements listed below. Molybdenum, the latest addition to the list, has for some time been known to be essential for plant growth, but evidence for its role in animal nutrition was first obtained about 1953 (16). It is now known to be a constituent of the enzyme xanthine oxidase.

Mineral Elements Essential for Animals

Calcium	Manganese
Phosphorus	Iron
Magnesium	Copper
Sodium	Zinc
Potassium	Cobalt
Chlorine	Sulfur
Iodine	Molybdenum

All of these elements are essential from the physiological standpoint. Fortunately, however, almost any practical combination of animal feedstuffs will meet the animal's requirement for many of the mineral elements, and the feed manufacturer need not give serious attention to them. Of greatest concern from a practical standpoint are calcium, phosphorus, sodium chloride, manganese, cobalt, and iodine. As will be pointed out later, iron and copper are also important in some areas. Ordinarily no special attention needs to be given to magnesium, potassium, zinc, molybdenum, and mineral forms of sulfur.

During recent years the study of mineral metabolism has not been able to compete in glamor with studies of folic acid and vitamin B_{12} and the exciting role of antibiotics. The fact remains, however, that the essential mineral elements are as important from a practical standpoint as vitamins or amino acids. They play a much more critical role than antibiotics. Figure 1 illustrates an example of the important functions of minerals in animal metabolism.

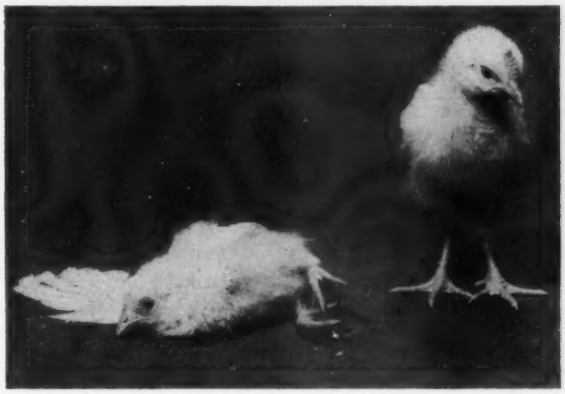

Fig. 1. Severe phosphorus deficiency in a young chick, left, contrasted with normal chick of same age.

Effects of Soil Fertility and Regional Deficiencies on Mineral Content of Feeds

It is important that chemists and nutritionists concerned with the formulation of feeds recognize the connection between soil fertility and animal nutrition. Problems of soil productivity, of biological value of crops, and of maintenance of health in our animal and human populations are inseparable. Virgin soils of high fertility produce feed and forage crops containing minerals and other nutrients at the highest level consistent with their genetic constitution. On the other hand, continuous cropping of soils without proper fertilization and crop rotation leads to erosion and mineral depletion and hence to poorer quality and lower yields of feed and forage (7).

The need for supplementary minerals in manufactured feeds may, therefore, vary appreciably with soil fertility. The influence of local soil conditions is especially pronounced in the nutrition of sheep, horses, beef cattle, and dairy cows, which consume a high proportion of home-grown forage. Not by accident is the area around Lexington, Kentucky, so noted for marvelously developed race horses. Lime and phosphorus in the soils of this area produced excellent skeletal frames in those prize-winners and their ancestors long before the advent of manufactured feeds.

Regional mineral deficiencies are not a question of soil depletion alone. Certain sections of the country are naturally deficient in one or more essential mineral elements; phosphorus deficiency, for example, occurs in at least a score of states in this country. For most purposes

[1]Manuscript received July 5, 1955. Presented at the 40th Annual Meeting, St. Louis, Missouri, May 1955.

these areas have always been deficient in this element, regardless of the type of agriculture practiced.

Cobalt, iodine, copper, and iron also are deficient in the soil of some areas. Florida has made excellent progress in developing an animal agriculture, particularly in beef — only, however, since the necessity of supplying animals with trace amounts of cobalt, iron, and copper has been appreciated. The feed manufacturer operating in such areas needs to be very much aware of this situation, to produce adequately balanced feeds with the proper mineral supplements. He must also realize, especially if he operates over a wide area, that because of the regional nature of mineral deficiencies in soils his problems are not the same throughout the country.

Biological Availability of Mineral Elements

Another matter of considerable importance in feed manufacturing — the biological value of the sources of minerals — is only now beginning to be fully appreciated. In the early days of nutrition research, investigators worked long and hard in proving that animals can utilize the inorganic form of many elements such as phosphorus and iodine, as well as their organically bound forms. Later it was rather widely assumed that all inorganic chemical forms of an element such as phosphorus were of equal feeding value. More recent studies have shown that this is not the case, and that a given weight of an element from one source may be less effective than the same amount from another source. The current importance of this subject warrants our considering it in more detail, by way of studies on the availability of phosphorus.

When the feed manufacturing industry was in its growing stages bone meal was the principal, and almost the only, supplementary source of phosphorus used. As the industry expanded and the demand for supplementary phosphorus increased, the supply of bone meal fell far behind and new phosphate products were developed from natural mineral sources such as phosphate rock and from phosphoric acid (2, 3, 4, 6, 12, 15). World War II greatly accelerated these developments. Some of the phosphorus products now in use are defluorinated phosphates, dicalcium phosphate, colloidal phosphate, imported rock phosphate from Curaçao and Mexico, and, of course, bone meal.

To evaluate these products and various products within each category, it has been necessary to develop suitable techniques for studying biological availability. The first tests were based on the solubility of the supplements in weak acid solutions similar to those used to measure availability of plant nutrients (12). It has been found, however, that these solubility tests do not correlate well with actual feeding experience (8). Other quick tests, such as microbiological assays, have shown little promise.

It has been concluded, therefore, that there is no satisfactory substitute for animal feeding tests to determine biological availability of mineral supplements (11). Since the greater part of phosphorus supplements finds use in poultry feeds, the writer's research in this field has been devoted primarily to studies of phosphorus availability in avian species. A procedure has been developed which is essentially a biological assay for availability employing a basic chick diet composed of purified-type ingredients very low in phosphorus (see table below).

Low-Phosphorus Chick Diet

	%
Blood fibrin	20.0
Gelatin	4.0
Cellophane	3.0
Soybean oil	3.0
Fish liver oil	0.25
Liver "L"	1.0
Salt	0.5
Mineral mix	0.8
Vitamin mix	0.5
Ca and P supplement	*
Corn starch, to make	100.0

*Varies with the experimental treatment.

The chief difficulty in formulating a diet low in phosphorus, that of finding a satisfactory protein supplement, has been met by the use of blood fibrin, a protein of high biological value but very low in phosphorus. The basic diet, unsupplemented, contains about 0.03 to 0.05% phosphorus, an amount which will not support life in the young chick for more than a few days. When phosphorus is added to this diet at appropriately increased levels, the chick's response in growth and bone calcification is proportional to the amount of available phosphorus provided. When the optimum amount of added phosphorus has been reached, growth and calcification are excellent, indicating that the diet is adequate in other respects. Use of this diet also assures that the test animals are receiving significant amounts of phosphorus from one source only, namely the supplement being studied.

Various supplements have been added at graded levels to this basic diet, care being taken that the highest level did not exceed the optimum requirement of the chick for phosphorus. Efficacy of the various phosphates has been measured by determining the percent of bone ash at the end of the assay period. For a careful evaluation the supplements should be fed for at least 3 weeks. At this time bone ash values are determined by the standard A.O.A.C. method (1).

When the basic diet is supplemented with beta-tricalcium phosphate, a type of response is obtained as shown in the curve in Fig. 2, where the percentage of supplementary phosphorus is plotted against the percentage of ash in the tibiae of chicks. The calcifying activity of pure beta-tricalcium phosphate has been assigned an arbitrary value of 100, used as a basis of reference in the same manner that well-characterized proteins such as casein or egg albumin have been used in studies on the nutritive value of proteins.

Figure 2 also illustrates the effectiveness of another phosphate and the manner in which its availability can be related to that of the reference material. The increase in bone calcification is sufficiently linear to permit valid comparisons between the curves.

This technique has been used to study a wide variety of inorganic phosphate supplements (11). For studies with phosphates of very low availability, the basic diet is com

posed of natural ingredients containing phosphorus in considerable, but still suboptimum, amounts. Some typical comparative values obtained are shown below.

Relative Biological Value of Some Phosphates

β-Tricalcium phosphate	100
Monocalcium phosphate	110-120
Dicalcium phosphate	90-100
Steamed bone meal	85-100
Defluorinated phosphate	80-100
Curacao Is. phosphate rock	65
Colloidal phosphate	25

These results indicate that there are sufficient differences in availability of the various phosphorus supplements to create a real problem for the feed manufacturer,

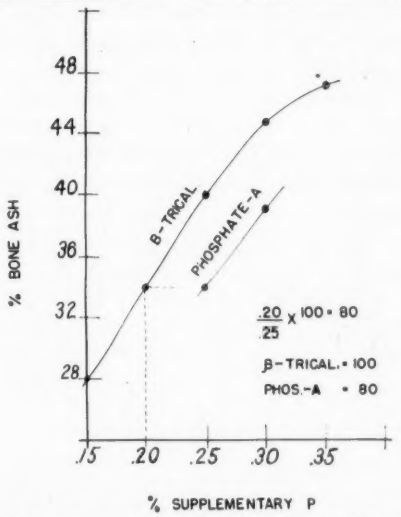

Fig. 2. This figure illustrates the effect of added beta-tricalcium phosphate in the low-phosphorus chick diet on calcification of the tibiae. It also illustrates the method of establishing comparative biological values.

one that he cannot afford to overlook. The cheapest sources of phosphorus may not represent the greatest bargain in terms of nutritional value and actual cost.

Availability of Phytin Phosphorus

Of considerable practical importance to the feed manufacturer is the availability of phytin phosphorus. Phytin is a complex organic phosphate, one of the principal phosphorus compounds in feed ingredients of plant origin. It consists of a mixture of the calcium, magnesium, and potassium salts of phytic acid. The majority of the phosphorus in such products as wheat bran and soybean meal is present as phytin. Since phytin contributes significantly, therefore, to the total phosphorus content of mixed feeds, its availability is of very considerable importance. The writer and associates have worked on this problem in relation to poultry nutrition (9, 10). More recently Chapman and associates at Iowa State College have given the problem attention from the standpoint of swine nutrition (5); they concluded that growing pigs utilize phytin phosphorus less readily than inorganic phosphorus from good sources.

Some of the results obtained with chicks fed with calcium phytate isolated from natural sources are shown in Table I. It is obvious from this table that the young chick does not metabolize phytin phosphorus very readily. Similar results have been obtained with phytin intact in

TABLE I

RESULTS OF REPLACING INORGANIC PHOSPHORUS WITH PHYTIN ON GROWTH AND CALCIFICATION IN CHICKS

Units of Vitamin Da per 100 g Diet	Weight of Bone Ash under Varying Proportions of Inorganic Phosphorus and Phytin Phosphorus							
	Inorg. - 0.6% Phytin - 0.0%		Inorg. - 0.4% Phytin - 0.2%		Inorg. - 0.2% Phytin - 0.4%		Inorg. - 0.05% Phytin - 0.55%	
	g	%	g	%	g	%	g	%
20	325	46.9	295	42.0	211	29.7	...	....
40	319	48.2	307	46.1	229	31.6	...	....
80	...	....	313	45.1	246	32.3	132	27.5

the natural ingredients. In similar studies, laying hens utilized phytin more effectively than chicks, but not so efficiently as they utilized good sources of inorganic phosphorus.

In investigations of the assimilation of phytin phosphorus by dairy cattle, Mathur (14) observed that 35 to 51% of ingested phytin phosphorus passed unchanged and unabsorbed through the digestive tract of cattle. Jarl (13) concluded that cattle utilize phosphorus in wheat bran about two-thirds as effectively, and in oats about one-third as effectively, as a readily available source of inorganic phosphorus. Supplementation of the ration with additional vitamin D slightly improved the utilization of phosphorus from wheat bran.

The significance of these studies with phytin phosphorus is fairly obvious to the feed manufacturer: analysis for total phosphorus is not a reliable index of adequacy of this element in the ration. The form in which this phosphorus is present is probably of equal importance. Swine and poultry rations, particularly, should be supplemented with adequate sources of inorganic phosphorus.

Toxicity Problems

Another difficulty in mineral nutrition is that of toxicity. Flourine, arsenic, selenium, and molybdenum are toxic to animals in relatively small concentrations. Of greatest importance is fluorine.

Two factors have increased the hazard of fluorine in recent years. One of these is contamination of local areas by effluent gases from metal and mineral processing industries. A much more serious problem has been created by unsafe levels of fluorine in feeds. The widespread use of colloidal phosphate and other unprocessed phosphate rock products has greatly increased the fluorine intake of our animal population.

Fluorine is a cumulative poison, the effects of which are particularly severe in ruminants and other animals having a long life-span. The first tissue to show damage is the teeth, the effect varying with the concentration of fluorine and the age of the animal at the time of exposure. Accumulation of fluorine causes discoloration, pitting, and excessive erosion. Cattle also show the effects of such poisoning in a typical unthrifty condition and rough hair coat. In several instances in this country and in Canada, valuable dairy herds have been wrecked

by long-continued feeding of fluorine-bearing mineral products.

Since evolution has denied dentures to poultry species, they are more tolerant of fluorine than swine or ruminants. However, their growth and well-being also may be adversely affected by fluorine.

Miscellaneous Problems

The foregoing are believed to be the feed manufacturer's most important mineral nutrition problems, but there are others. Considerable pressure is sometimes exerted in the form of extravagant claims for benefits to be derived from trace elements. One claim for these micronutrients, which has since been disproved, was the cure of Bang's disease. Fortification of feeds with trace elements is necessary or desirable in many areas. Where the need is less clear-cut, the manufacturer may still wish to add them as insurance against deficiencies. This can be done without significantly increasing the cost to the feeder. However, extravagant claims based on the addition of trace minerals should be shunned.

The importance of maintaining the proper ratio of calcium to phosphorus in the ration is well known. It is also unnecessary to dwell on the relations between molybdenum and copper and between sodium and potassium.

Of perhaps more interest is the effect of growth stimulants and high-energy feedstuffs on the mineral requirements of poultry and livestock. There seems to be no evidence to show that the animal's physiological requirement for minerals has been significantly altered by any of these recent changes in feed formulas.

For maintenance, an animal of a given weight requires a certain daily intake of minerals. For growth an additional amount is needed, which depends on the rate of growth. The animal appears to eat primarily to satisfy its energy requirements for maintenance, growth, reproduction, and lactation. When its caloric requirements are satisfied it ceases to eat temporarily. When the ration is high in calories, or some additive is present which increases the efficiency with which those calories are converted to fuel or tissue, less feed will be required per day or per pound of gain. Thus, while the animal's daily requirement for a given mineral remains the same regardless of the ration eaten, it may be desirable to raise or lower the percentage of that mineral in the ration, depending on its productive energy content. The habit of expressing nutritive requirements in terms of percentages of the total ration may be getting out of step with the times and we should adopt a better way, perhaps in relation to calories of productive energy.

Summary

Manufactured feeds are used under widely varying conditions of farm management and soil fertility. Where such feeds are used to supplement locally grown grain and forage, they must counterbalance mineral deficiencies in the home-grown products caused by soil depletion or natural soil deficiencies. Most grains and forages, regardless of the area in which they are grown, are deficient i one or more minerals.

Different chemical forms of mineral supplement notably phosphates, vary in biological availability. The cannot be used interchangeably without consideration t availability. The low biological value of phytin for pou try, swine, and possibly other species must be compe sated for in formulating rations. The amount of toxi mineral elements, especially fluorine, in the total ratio should be kept at levels sufficiently low to avoid the po sibility of harm to animals.

Quantities of minerals required in a ration are mor closely related to productive energy content than to fixe weight relationships between minerals and other ingredi ents. The objective of mineral supplementation is to e sure an optimum daily intake of these inorganic nutri ents. The optimum concentration of any mineral elemen in the formulation should, therefore, be determined b considering the effect of energy level on feed intake an rate of growth.

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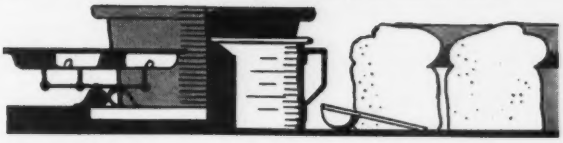
BAKING TECHNOLOGY



Oscar Skovholt Otto G. Jensen

SOFTNESS AS A MEASURE OF FRESHNESS

Many technical and production people have spent much time in attempting to increase the palatable life of bread. The phenomenon of staling is not well understood; it involves a firming of the product that occurs even when moisture loss is prevented. There is also a loss of flavor that may be thought of as actually beginning during the baking process, as indicated by the aroma that comes from the oven. Proper wrapping and storage conditions help somewhat in retarding some of the changes that occur with age, but the characteristics of freshness disappear with time.

This fact is realized by the shopper when she selects bread in the grocery store. The housewife does most of the buying and she chooses the products that best please her family. Likes may vary as to type of bread, but freshness is always wanted in the baked products that are selected. She has only one way of judging freshness in the store (unless time of baking is indicated) — and that is the "squeeze test."

This selection method has created a race among bakers to make bread with increased softness. Changes have been introduced through both formula and processing, with every baking laboratory trying to find how to produce increasingly soft bread. Suppliers of ingredients have a similar objective; they know that if extra softness can be produced by their ingredient without any loss in other qualities, sales will come easily. Certain emulsifiers have received particular consideration because of the aid they may give in increasing softness-retention during the time preceding sale, as well as in the bread box.

The processing change that has been most widely used to obtain extra softness has been reduction in amount of bake. This trend has been apparent everywhere but has been most pronounced in certain Southern areas. Many consumers consider that much of this bread is seriously underbaked, but still this apparently has not upset the tendency to pick the softest loaf on the grocer's shelf in an attempt to get the freshest product.

Other changes in dough development procedures as well as in cooling and wrapping practices are being continually tried in order to obtain extra softness. Types of wrapping materials are being evaluated with

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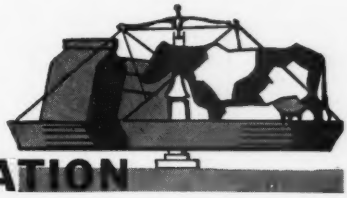
FEED AND FEED FORMULATION



S. F. Brockington Loren V. Burns

AUTOMATION AND THE FEED INDUSTRY

The word automation has been so highly publicized in recent months that the general public fully expects tomorrow to bring automatic factories, operated without human hands. In actuality the feed industry and its more patriarchal cohorts, the grain and cereal milling industries, have been automated for years, using highly mechanized material-handling systems and requiring a remarkably low number of man-hours per unit of output. In spite of this early mechanization, these industries have been slow to adopt more recent developments, including programming units and integrated control systems, or to utilize mechanical and electronic "brains" to tackle their more complex problems.

Undoubtedly the complexity of modern automatic control systems, coupled with the scarcity of personnel trained in design and application who at the same time are familiar with feed problems, has mitigated against extensive application of automation in the industry.

However, automation is now wedging its way into feed plants — witness recent installations of automatic batching controls, and programming units in both new construction and modernized existing units.

What will be the impact of automation upon management, purchasing, production, quality control, and even labor in the feed industry? Is automation something to fear, or to welcome with open arms?

Only through automation or associated techniques can the feed industry achieve the uniformity of product, minimum product cost, and economy of product performance which is becoming paramount today and certain to be demanded by the "consumer of tomorrow." However, the transition period will be difficult. Management is bound to fear the added plant investment required by automation; the production superintendent will resist the increased complexity, added maintenance, and need for more highly trained personnel; the purchasing agent may resist a change from intuitive market predictions to complex electronic-calculator techniques for predicting market trends and determining the risks involved in advance purchases of ingredients; and labor may resent machines taking over manual functions.

These fears of automation are legitimate, a natural result of fear of the unknown and resistance to change. They are further complicated by re-

(Please turn to next page)

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Baking Technology:

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this idea in mind.

Several procedures for evaluating internal softness of bread are very useful in helping to study changes that occur with age. These methods do not directly measure the external resistance of the wrapped loaf to the "squeeze test." They are a measure of staling rate, but do not take into account the variables due to crust characteristics and packaging materials. A device for measuring this external resistance to squeezing has been developed in the writer's laboratory. It may not be more accurate than the sensitive hands of a housewife in comparing the softness of several loaves, but it does have a "memory," since this resistance is read in absolute units.

Devices of this kind are useful in studying the properties of wrapped baked goods, but the readings obtained should not be used as a measure of quality. A change in merchandising methods may be needed to convince the housewife that the softest bread is not necessarily the freshest. Many consumers feel that a loss in palatability has occurred because of underbaking and the other evils that have developed because of this emphasis on softness. It would seem that the time is here for the baking industry to take united and drastic steps to produce bread that is "good to eat" instead of merely being made to pass the squeeze test.

OSCAR SKOVHOLT

Feed and Feed Formulation:

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cent trends in the feed industry which indicate a move away from extremely large centralized production units (which are cheapest to automate per unit of output) to a greater number of relatively small production units dispersed throughout the areas served. Such plants cannot individually support extensive automation units and complex "brains," yet they will need them to achieve product uniformity and low costs.

Automation is not an item that can be "slapped on" to an existing system; a frozen design or manufacturing process puts binding limits on the performance of automation or integrated controls. Leaders in automation and designers of automatic processes have repeatedly stressed the need for integrated-systems engineering.

Technical personnel will play an important role in the transition to automation. The production engineer must be prepared to analyze his processes and adapt them to automation. The quality control supervisor and analyst must seek analytical techniques suitable for continuous "on-stream" use, capable of feeding results into the automation system and effecting immediate corrective measures. Finally, management must educate itself to accept the increased cost and complexity of automation and to use the powerful management and control tools made available by automation, based upon linear programming and operations research.

LOREN BURNS